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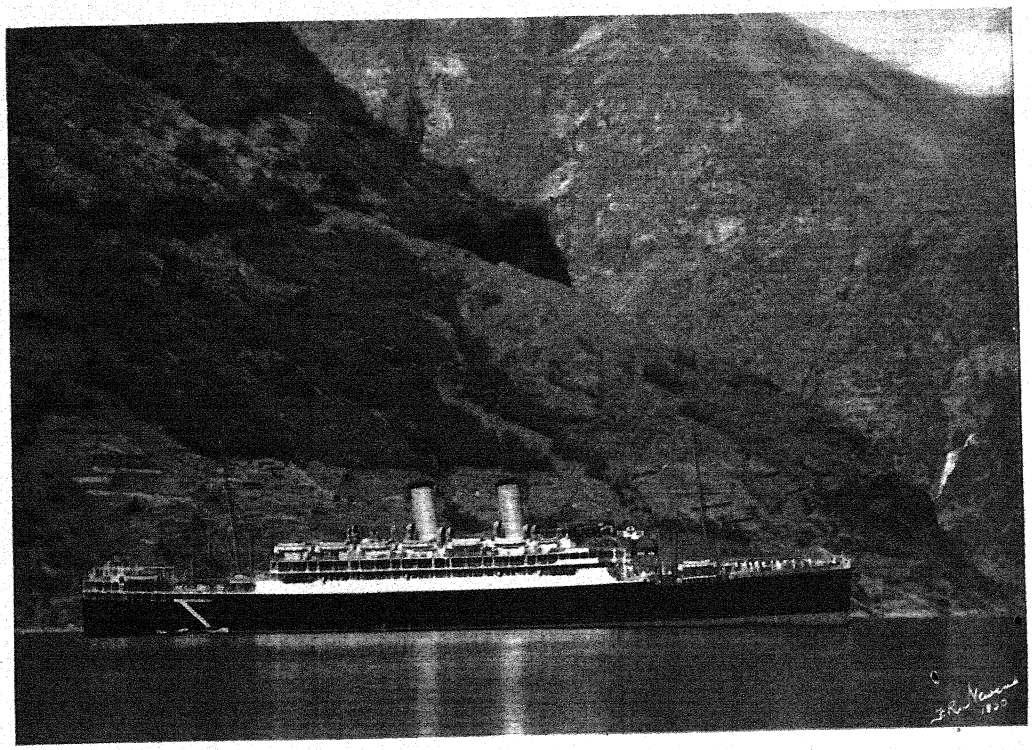

COLOUR PHOTOGRAPH OF R.M.S. *ORFORD* AT MEROK, NORWAY

(Negative taken with repeating back)

Frontispiece

The Technique of Colour Photography

39215

BY

FRANK R. NEWENS

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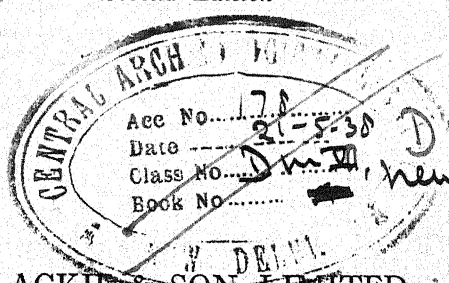

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PREFACE

When I was approached by the publishers of this work it was with some diffidence that I agreed to write a book upon the Technique of Colour Photography. This diffidence was the outcome partly of a wide and peculiar knowledge of my own shortcomings, and partly of the natural feeling that so much has been written on the subject already, that one wonders if it would be at all possible to deal with it afresh and in a fashion which would make the book fill some niche not already occupied by works of a similar nature. Then, too, at the request that a certain amount of theory should be incorporated —I was aghast at the thought! For the subject covers such an enormous field that even were I qualified to write thereon, how *could* I condense it so that the average photographer would consent to wade through it?

"Average photographer!" — those words brought to my mind the person who usually wishes to start upon colour photography. Believe me! it isn't the well-known pictorialist, nor the eminent scientific photographer who *starts* upon colour photography. It is the average photographer, the man or woman who, seeing some scene in nature ablaze with colour, sighs for the knowledge and means of reproducing those beauties by means of the photographic plate. He, or she, isn't particularly interested in *why* it is possible, but rather in *how* it is possible. And he, or she, more particularly she, perhaps, will only read or listen to theory in so far as it may be of actual assistance in the work itself. This characteristic —may I breathe it—is by no means the prerogative of the amateur.

So, thought I, it shall be for the average photographer. I lay

great stress on the actual details of the methods recommended, because unimportant as they may appear at times to be, they are the outcome of many years of painful experience and thought, devoted to the avoidance of snags which go to make all the difference between failure and success.

And theory! well, since of necessity at times some knowledge of theory is wanted, in this I have endeavoured to bring in what I feel *is* necessary, and I have tried to put it into some sort of sequence which shall show its bearing upon the problems that will have to be faced by the worker. Therefore in planning the book I have had in mind not what the reader *ought* to start with, but rather what I know he *will* (hence the placing of the chapters on colour printing before those on colour transparencies), notwithstanding that he may lessen his chance of success by attempting to run before he can walk. For run he will, so I have tried to help him.

I have based what theory I have introduced upon the questions I have been asked during the course of a good many years of demonstrating and lecturing upon the joys and sorrows of colour photography. If the more advanced worker who has previously delved into this sphere thinks it somewhat elementary, may I remind him that it is designed for the beginner, and similes which may appear to partake a little of the schoolroom are helpful even to minds which left such scenes behind them a good many years ago.

In this second edition I have brought the little book thoroughly up to date and have included processes not hitherto available. For permission to use figs. 4–12, illustrating the new Carbro process, I am indebted to the Autotype Co., Ltd.

FRANK R. NEWENS.

OXFORD,
May, 1936

CONTENTS

CHAPTER I

PRINCIPLES OF COLOUR AND COLOUR PHOTOGRAPHY

CHAPTER II

EXPOSURE

CHAPTER III

THE SUBTRACTIVE PROCESSES

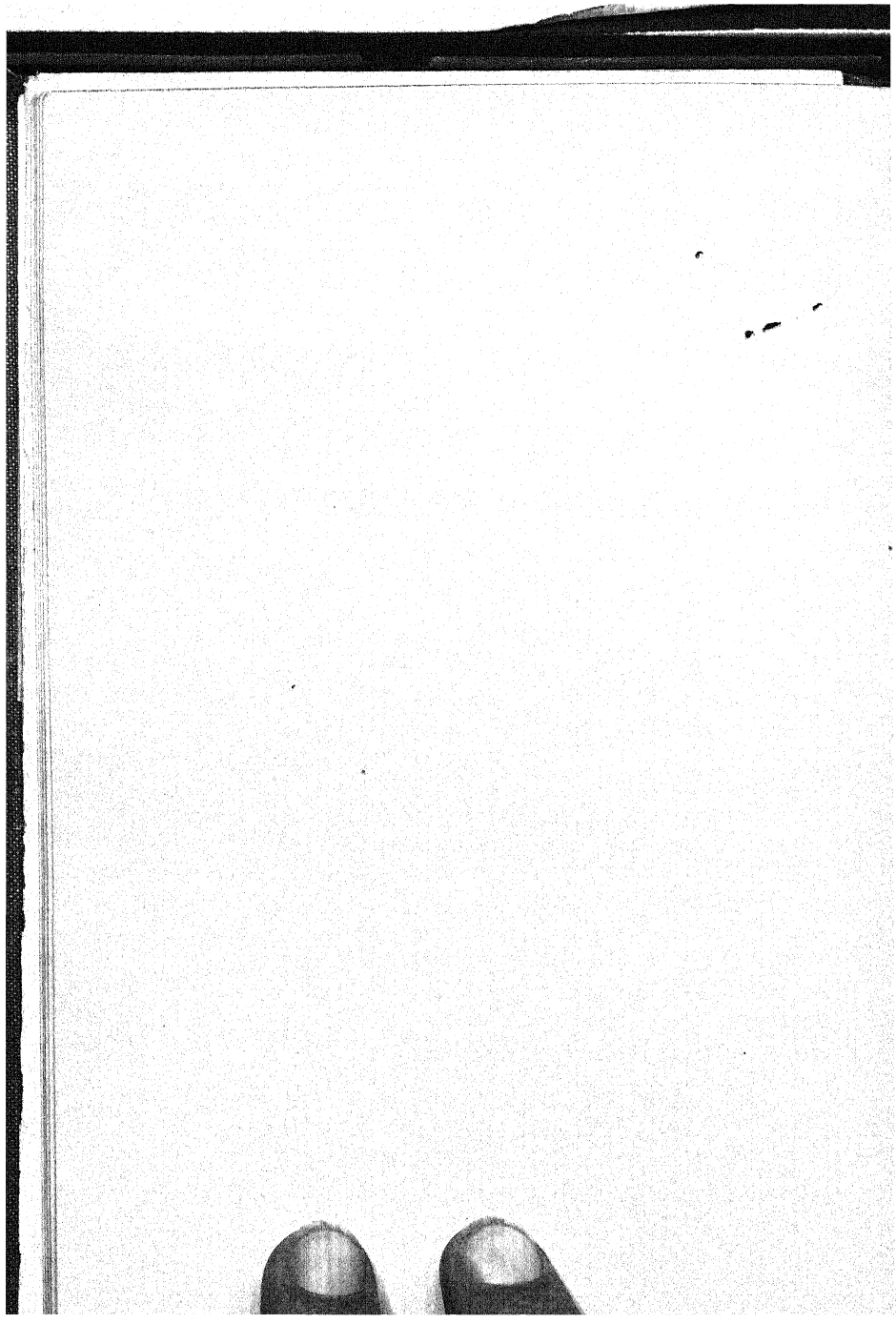
CHAPTER IV

COLOUR PRINTS FROM COLOUR TRANSPARENCIES

CHAPTER V

THE MOSAIC SCREEN PROCESSES

LIST OF PLATES



THE TECHNIQUE OF COLOUR PHOTOGRAPHY

CHAPTER I

Principles of Colour and Colour Photography

Historical Introduction

It has been the desire of photographers since the earliest days of photography to be able to record, by means of the camera and photographic plate, not only the contours and modelling, the high-lights, half-tones, and shadows of the object photographed, beautiful though these may be, but also the actual colours of nature itself.

The starting-point of photography may be ascribed to the idea born of the brain of Thomas Wedgwood (the son of the most famous of English potters) which suggested to him the possibility of recording objects by the action of light, and which was described by Davy in the *Journal of the Royal Institution* in 1802. A period of some thirty years passed by before, in August 1835, the first authenticated photograph was taken, that of a window in Lacock Abbey, by William Henry Fox Talbot. This is generally considered to mark the birth of photography as we know it to-day, employing both a negative and a positive. Daguerre invented his process about the same time, communicating " his perfected process of obtaining permanent pictures by sun action ", as it was somewhat quaintly described, to the French Academy in 1839.

Curiously enough, an almost similar period of time elapsed before any new idea emerged to elucidate the problem of photography in natural colours. For it was in the year 1861 that the great scientist Clerk-Maxwell enunciated his theory that all the colours in nature could be matched by the proper admixture of three primary colours selected from the spectrum —red, green, and blue-violet. Upon this discovery it may be claimed that all subsequent attempts, successful and unsuccessful, at colour photography have been based, with the possible exception of the process invented by Professor Lippmann, a process of great scientific interest, but unfortunately of no practical value.

Speculative details of methods of employing Clerk-Maxwell's discovery were given by Ducos du Hauron about the year 1868, but, lacking suitable materials (the panchromatic plate was unknown in those days) and receiving but scant encouragement from the French societies devoted to the interests of photography, du Hauron was unable to put his theories into successful practice. This was first done almost simultaneously by two men working upon the lines indicated by du Hauron, namely, Professor Joly of Dublin, and MacDonough of America. Joly is generally looked upon as being the first actually to produce results, but MacDonough forestalled Joly in patenting his shellac-grain screen-plate process in 1892, two years before the latter brought his line screen plate into public notice. Shortly after this the brothers Lumière invented their starch-grain process, but it was not until the year 1907 that this process, which has since proved to be one of the most successful of transparency colour processes, was placed upon the market. This was followed in 1913 by the Paget process, which was a modification of an earlier process known as the Thames screen-plate.

The year 1924 saw the reintroduction of the Agfa process (it was first produced in Germany during the Great War in 1916), which was soon followed by the " Lignose " colour screen film, the first colour process upon roll and flat film

to be placed upon the market. This, though it produced some exceedingly fine results, was not long in existence, as the difficulties of working the film in the roll were considerable, and it was finally absorbed by the Agfa Company and taken off the market.

This brief outline of the history of some of the best-known colour processes takes no account of the many methods connected with what are known as the subtractive processes, i.e. those processes which are mostly concerned with the production of print upon paper. Few of these, however, have reached a stage of simplicity that would be attractive to the average photographer; and since it is with such processes as have reached that stage of development, and have survived, that this book is to deal, it will suffice to defer mention of them to a later page.

Principles Underlying Colour Photography

Before describing in detail any of the above-mentioned processes, it is desirable that some idea of the principles underlying the practice of colour photography should be given, in order that the reader may understand what is meant by " colour ", and have some notion of the physical phenomena with which colour is associated, so that he may be provided with a moderately clear idea of the problems involved in his labours. It is hoped that this knowledge will not only make his hobby more interesting, but will help him in its actual practice, since it should to a very large degree enable him to see the reason for doing certain things and for avoiding others which are only a waste of time. In colour photography suggestions are apt to present themselves which are superficially promising, and upon which much time and labour may be expended, but a knowledge of the theory underlying practice will put the reader in a position to discard many of these suggestions at once, as impracticable and valueless. It is doubtless true that such knowledge is not essential to successful practice, and the following notes may be passed

over if the reader so desires; yet it will frequently be found of great assistance if a clear understanding of the underlying principles is possessed by the worker.

Everyone to-day is aware that white light, such as sunlight, is not quite the simple " oneness " (if so it may be described) that perhaps as children we were apt to imagine it to be. The rainbow, which we see when the sun's rays fall upon the raindrops of a distant shower, tells us that. We know that the light of the sun, in some remarkable fashion, can be split up into those beautiful colours, which we see in even greater intensity and brilliance, thrown upon the ceiling or wall, when a narrow beam of sunlight falls upon the bevelled edge of a mirror, or the cut-glass stopper of a bottle, though possibly we may not have speculated upon the connexion between these phenomena and colour photography.

It is common knowledge, of course, that a similar result can be produced at will by passing a ray of light through a diffraction grating, or a glass prism, when this same band of colours, the spectrum as it is called, can be seen emerging from it. That these colours are really the original beam of light in an altered form can be proved by placing a second prism, of similar angles, in reversed position, against the first, when the light will be seen no longer in its component parts, but proceeding from the second prism in the form in which it entered the first.

When one contemplates the enormous variety of tints and colours, the statement that any colour in nature can be matched by the admixture of three only, seems at first sight a somewhat staggering one to make. It will, however, be easier to comprehend if the question of what is meant by " colour " is gone into a little more deeply.

For the moment the " wave " theory of the nature of light will not be dealt with, though at a later stage it will be necessary to delve a little into this rather more complex side of the problem.

Nature of Colour

When we see a coloured object, be it a flower, or a brightly coloured piece of silk, or what not, we know that no matter how brilliant the colours may appear we shall not be able to see them in a completely darkened room, but that light of some kind must be present if we are to discern them at all. We realize, therefore, that colour is not a property of the object alone, but that it is dependent upon the presence of light. The reason that objects appear coloured is because they possess the property of absorbing some of the rays of light falling upon them while reflecting others. Transparent objects such as coloured glass and gelatine (the materials of which the colour filters are made which we shall use later) also possess this property of absorption, absorbing part of the light falling upon them and *transmitting* the remainder. Colour is the result of the absorption and the transmission, or reflection, of light.

As a simile, though perhaps not a very exact one, one may instance water running from a tap on to a sponge. Part of the water will be absorbed by the sponge, and part will splash off. In much the same way, part of the light is absorbed by objects and part is splashed off, or is reflected, and according to that part which is reflected, or in the case of a transparent medium, " transmitted ", so we name the colour we see. Objects which transmit, or reflect, *all* the rays of the light which falls upon them we call white or colourless, and those which absorb the whole of the light falling upon them we term black, for black is an entire absence of light. When the object absorbs an *equal* part of *all* of the rays of which the incident light is composed, we speak of it as being a neutral grey.

The Spectrum

To return to the colours in the rainbow, or the spectrum, as it is more properly called, what is the reason for the appearance of these colours? Why is white light broken up into its

component parts under such conditions? It is because the light on entering the raindrops, or the glass prism, is bent out of its original path. We are all familiar with the appearance of a walking-stick when it is poked into the transparent waters of a pool or stream—how the portion under the surface of the water appears to be bent slightly upwards; this is another instance of the bending of light, or refraction as it is called. If we take a rod made up of a number of splinters, say a cane rod that has been hammered until it has separated into its individual fibres, and if we bend such a rod, the fibres or splinters will spread out fanwise, showing the separate portions distinct and apart; so with light entering a medium such as the glass prism, or the spherical raindrop, the rod or ray of light bends and is split up into its component parts. In white light, such as sunlight, these components form a continuous band of colours ranging from deep violet at one end, through blue, blue-green, green, yellow-green, yellow, orange, to deep red at the other end. This is known as the visible spectrum. There are in white light, however, other wave-lengths, or portions of the spectrum, which are invisible to the human eye but to which the photographic plate is, or can be made, sensitive. They are the " infra-red ", which extends beyond the red end of the spectrum; and, at the other end beyond the violet, the " ultra-violet " rays. To these latter the emulsion of the photographic plate is especially sensitive, as will be learned later.

Seeing that the photographic plate, although it can be made sensitive to every colour in the spectrum, is not equally sensitive to them all, special arrangements have to be made to compensate for this. In the screen-plate processes, this is done by using what is known as a compensating filter over the lens of the camera; in the subtractive processes, where three separate colour negatives are made, as required by the Clerk-Maxwell theory, the exposures of the negatives are varied to make up for this variation of sensitivity.

Sunlight has this continuous spectrum band, and is always

composed of the colours indicated, but the proportionate amounts of these colours differ according to different lighting conditions. For instance, on a bright June day the band of violet and blue would be found to be of a greater strength than say towards evening in September, when the red and yellow bands would appear brighter. This, of course, is not due to an actual change of the light radiated from the sun, but rather to the atmosphere acting as a filter, which is a transparent medium absorbing some part of the rays—not necessarily completely absorbing any particular band of the spectrum (indeed if it did one could not at that moment successfully reproduce the colours of nature by any method based upon Clerk-Maxwell's theory), but rather absorbing a part of several bands.

Artificial Light in Photography

This variation in the composition of sunlight brings us to the question of the use of artificial light for colour photography. In answer to the query, can colour photographs be taken by artificial light, one can reply "Yes, provided the spectrum of that light *is* a continuous one." There is only one light likely to be met with in photography which is quite unsuitable for colour photography, namely, the mercury vapour lamp, though, curiously enough, this is very efficient for monochrome photography, and is used very largely for many branches of commercial photography. It owes its efficiency for monochrome photography to its richness in ultra-violet rays, to which, as has been stated, photographic material is exceptionally sensitive, but its uselessness for colour work is due to the almost complete absence of red rays in its composition. One can easily understand that if there is no red in the light itself any object which we normally call red if seen in this light will not appear red, but in the complete absence of any of those red rays which alone the object has the power to reflect, it must and will appear black, since all the light that falls upon it is absorbed by it. This, of

course, is the reason for the ghastly and death-like appearance of a ruddy-complexioned person seen in this light. The red lips, the pink of the cheek, absorb the light and appear black and grey respectively, while the whiter portions of the face reflect the colour of the light itself (white light minus red), a peculiar bluish green.

It will therefore be seen that, apart from a light such as that of the mercury vapour lamp, artificial light is quite suitable, though, as will be gathered from what is stated above, the spectral quality of the light has to be taken into consideration. Fortunately this involves no special knowledge or skill of any kind on the part of the worker, other than the ability to read and use the multiplying factors given for the particular light in use by the plate-makers themselves; but consideration of the above-mentioned differences in the composition of various light sources, and the inequality of sensitivity of the plate to different parts of the spectrum, should make it clear that it is not possible to use a mixture of lights of widely different spectral quality when taking colour photographs. In fact, under such circumstances, the object would be illuminated by light to which the plate used is variously sensitive, and the result would be a curious patch-work of colour totally unlike the appearance of the object to the eye. Do not, therefore, mix half-watt and arc-light (unless the arc is the so-called " flame arc ", which is very like the half-watt in spectral composition), nor artificial light and daylight, except when the composition of these is very nearly alike. We have perhaps gone somewhat far ahead, but the question of mixing lights is so often brought up that we feel it may quite properly be touched upon when dealing with the composition of light, since the *reason* for the answer given can then be understood.

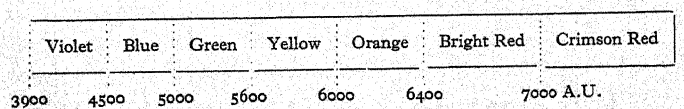
Physical Nature of Light

Before we proceed to the application of Clerk-Maxwell's theory to the practice of colour photography, we have still one or two theoretical points to consider.

The first point refers to the physical nature of light itself. The theory generally held to-day is that light is a form of energy which travels with a wave-like motion in the ether—that substance which is presumed to pervade all space and matter. Light waves may be likened to waves of sound, which vary in frequency of vibration. In sound, there are vibrations of high frequency, which our ears apprehend as high pitched or treble notes, and also vibrations of lower frequency, where fewer waves per second fall upon the ear, thus producing the bass notes of speech or music; so with light there are waves of varying frequency of vibration producing different results upon our optical receptive system. Some of these fall upon the eyes at a comparatively low frequency, others at double, or even a higher rate of vibration, and the colour of the light varies according to the rate of frequency of vibration.

The waves themselves are imagined to be similar in form to those caused when a stone is dropped into the still waters of a pond, which go travelling outwards in a series of crests and troughs—the wave-length being compared to the distance between crests of consecutive waves. The velocity of light is known; it travels through empty space or through air at the stupendous rate of nearly 200,000 miles per second. White light such as sunlight may be compared to sound in another respect also, since light consists (as we see in the spectrum) of waves of varying frequencies; and further, there are harmonies of colour as there are harmonies of sound. The distance from crest to crest of successive light waves is exceedingly short. These distances have been measured, the unit of measurement being known as an Ångström Unit (A.U.), which is a ten-millionth of a millimetre.

The diagram shows some of the wave-lengths in the spectrum together with the colours to which they correspond:



Colour and Vision

We may now consider how it comes to be possible to reproduce all the colours of nature with only three colours. To understand this, we must examine the theory generally held, and now fairly well substantiated, as to how the eye perceives colour. Many theories have been advanced from time to time purporting to explain the process by which the brain differentiates between various colours. The theory accepted at present, which was first enunciated by Thomas Young, is based on the hypothesis that we possess only three fundamental colour sensations. In our eyes there are supposed to be three kinds of nervous elements, which are stimulated by these three fundamental colours. One is stimulated most strongly by wave-lengths of light near 6000 A.U. in the orange-red portion of the spectrum; another by those in the yellow-green portion, and a wave-length of about 5600 A.U.; the third by the blue region round about wave-lengths of 4650.

These nervous elements, or fibrils, may be likened to three wireless sets, one tuned or adjusted so that it would receive signals from the London broadcasting station at 261 metres, another from a station at 356 metres, and a third from the Midland region station at 479 metres; and just as these sets would only be stimulated by the wave-lengths to which they were tuned to respond, so, too, it is supposed the sensitive fibrils in the eye respond to the wave-lengths indicated. The simile may be stretched even further, for as the wireless sets will receive signals a little on either side of the specified wave-band, though not so strongly as those for which they are specially tuned, so it is supposed the nerve fibrils are also excited in a lesser degree, but through a considerable range, by the wave-lengths of light on either side of the maxima.

One is obliged to emphasize that the existence of these fibrils is based solely upon the assumption that something of the kind must be imagined to exist, since no trace of any such nerves has yet been discovered by the physiologist.

When all three of these nervous elements are strongly and

equally stimulated by light emanating from one source, the brain receives the impression of white; if equally, but more feebly, then the impression received is of grey; and according to the degree and intensity of the stimulation of one or more of the elements, so the impression of colour, of a corresponding degree of brilliance or intensity, is received by the brain. Thus, for example, if only the element sensitive to green is stimulated, the brain receives the impression of green; and other colours than the primaries are the result of the stimulation of more than one nerve fibril. It should be pointed out that if the patches of the primary colours are exceedingly minute, the eye is then unable to see them as separate units, and the whole area appears white. This is the property of vision upon which the mosaic screen-plate processes are based. It is analogous to " persistence of vision ", the well-known phenomenon which has made the cinematograph possible.

Experiment showing Blending of Primary Colours

In order to bring out more clearly how these theories fit into practice we will now describe an experiment which has been used to give an ocular demonstration of the results of blending lights of the three primary colours (see Plate, p. 12).

If either a triple lantern, or three lanterns, are so fixed that the beams issuing from them fall upon one and the same place on a whitened screen, it will be obvious that we shall have a circle of white light at that place. If, however, before illuminating the screen in this way, we take one lantern only, and if in the path of the beam of light coming from it we place a piece of gelatine dyed with one of the primary colours, say the blue-violet, then the circular patch on the screen will be of that colour. If now we add a beam from a second lantern, and in its path interpose a filter, as it is termed, of red, then we shall see on the screen a mixture of red and blue-violet, which is generally called magenta. If finally we turn on the third lantern with a green filter in position, we shall find that all

colour has disappeared from the screen, on which there will now appear a circle of white light similar to that seen at first, though perhaps, owing to the absorption of light by the filters, of somewhat lowered brilliance or intensity. The fact that we are able to produce white light by the admixture of the three primaries may be regarded as explaining why it is unnecessary to employ as many colours as can be seen in the spectrum, since if it is possible to produce the whole source of colour in this way, it must be possible to reproduce any part of the whole.

The reason why we see this mixture of coloured lights as white is because the nerve fibrils have been equally stimulated, the eyes being focussed upon one patch of light.

If now the light from the blue-violet lantern is extinguished, the colour seen upon the screen will be a bright yellow, because in this case only the fibrils stimulated by red and green are excited, and when this is the case the brain receives the impression of yellow.

It should be borne in mind that at the moment we are dealing with the effect of the admixture of coloured *lights* and not pigments.

The diagram facing this page deals with the admixture of coloured lights, which in photography is known as the additive method. The diagram has been modified somewhat in form, the circles of light from the three lanterns being made to overlap for the sake of clarity and in order to explain the meaning and formation of the complementary colours.

Filters

The three primary colours are used in the form of filters to analyse the colours of the object photographed. Filters are used in many forms, but in any case they are employed somehow or other in front of the panchromatic emulsion of the plate or plates so that the light reflected from the object has to pass through them before it can act upon the plate itself.

It must be borne in mind that we never encounter in nature

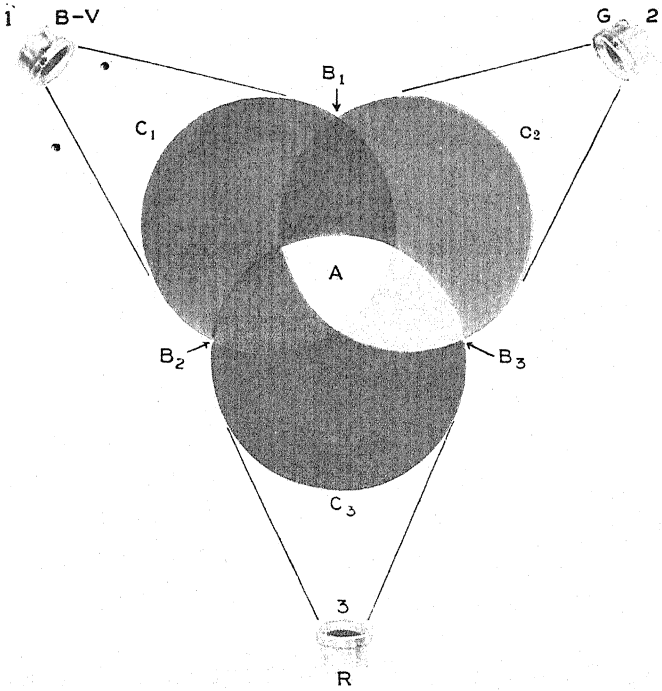


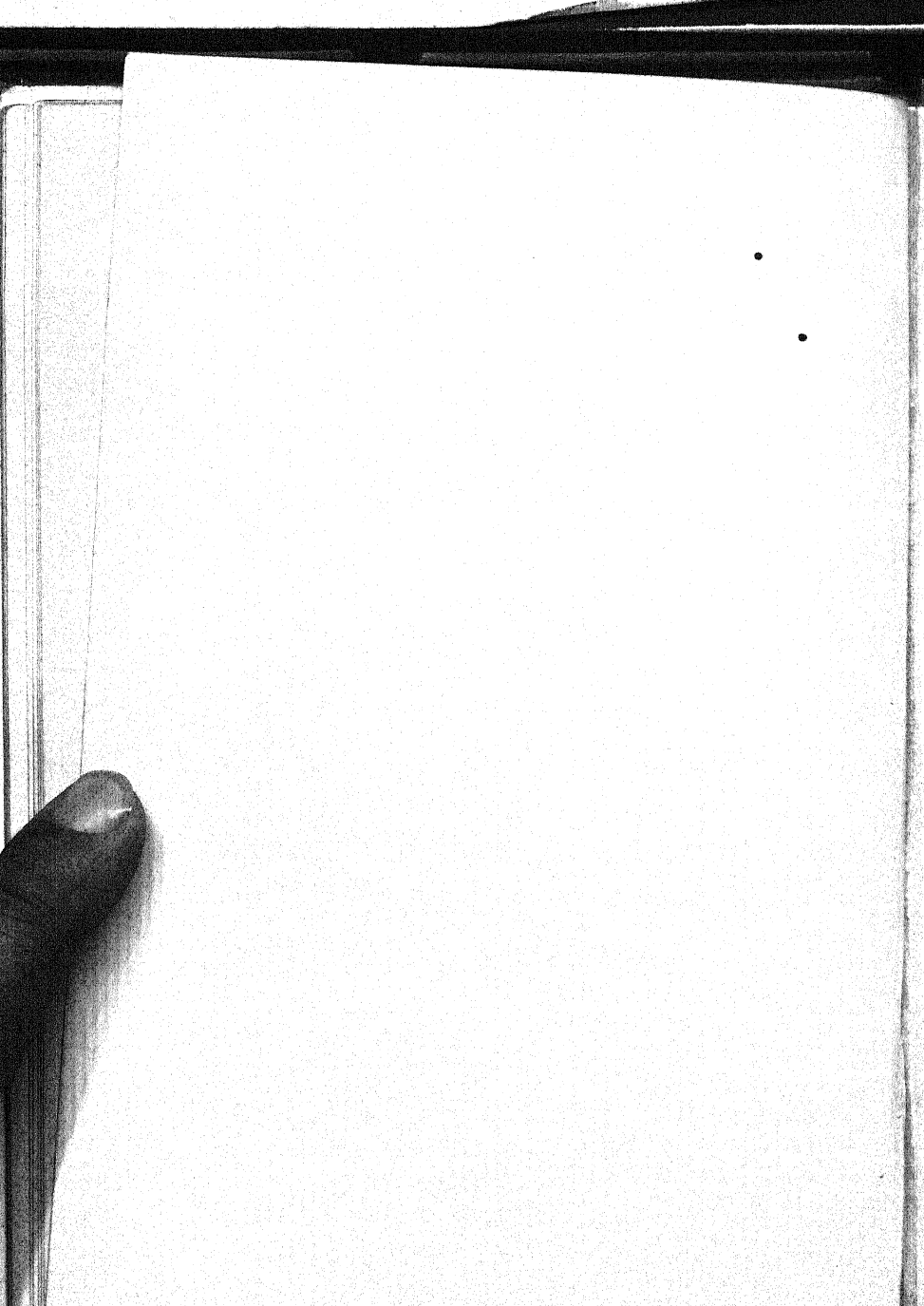
DIAGRAM ILLUSTRATING THE ADDITIVE METHOD OF COLOUR PHOTOGRAPHY

This diagram shows the three lanterns throwing beams of blue-violet, green, and red light upon the screen, with the circles of light overlapping at A. White light is formed at A by the superposition of the three primaries C_1, C_2, C_3. The formation of secondary colours is brought about by the superposition of two of the primaries; these colours are also known as the complementary colours:

B_1, Blue-green is complementary to Red;
B_2, Magenta is complementary to Green;
B_3, Yellow is complementary to Blue-violet.

C_1, C_2, C_3: the primary colours as projected by the lanterns.

Note.—The complementary colours B_1, B_2, B_3 are the colours used in the subtractive processes for making the colour positives from the negatives taken through filters of the primary colours.



any colours which are absolutely pure spectral colours. The greens, reds, or blues are never exactly the same colour as our green, red, or blue primary colours, but are always mixtures of these. We therefore use our primary colours in such a manner that they act as filters, and filter out as it were (or more correctly absorb) any colour that we do not want to act upon the plate. Thus filters are used as a means of producing photographic records of the amount of blue-violet, green, or red contained in the colours of the object. The filters may consist of thin sheets of gelatine dyed the primary colours, or they may be tiny irregular dots of gum or resin or of starch grains, or they may consist of regular squares or lines printed on glass or film; but no matter what form they take their purpose is the same, namely, to analyse the colours of the subject photographed and to form a photographic record of their amounts. In the screen-plate processes they are used in the dot form, either actually on the same plate as the emulsion, or on another in close contact with it.

The Additive Process

In order to make it clear how the colours are formed in the additive process we shall suppose that we are given a circle of pure red against a white background (facing p. 14).

A negative is taken of this through the blue-violet filter and would appear as diagram A, i.e. a black outer square with a circle of clear glass in the centre corresponding with the circle of red. In this case the filter passes the blue-violet reflected by the white background and gives a black image on the plate. It absorbs the red rays reflected from the card and therefore no action takes place upon the plate in that area. If this negative were put into a lantern and projected through a blue-violet filter we should have a black outer square and a blue-violet circle—the opposite of what is required. A positive A_1 has therefore to be made from the negative A.

A second negative is taken through the green filter and would appear as diagram B, for precisely similar reasons as

in the case of A. A positive B_1 is therefore made from B.

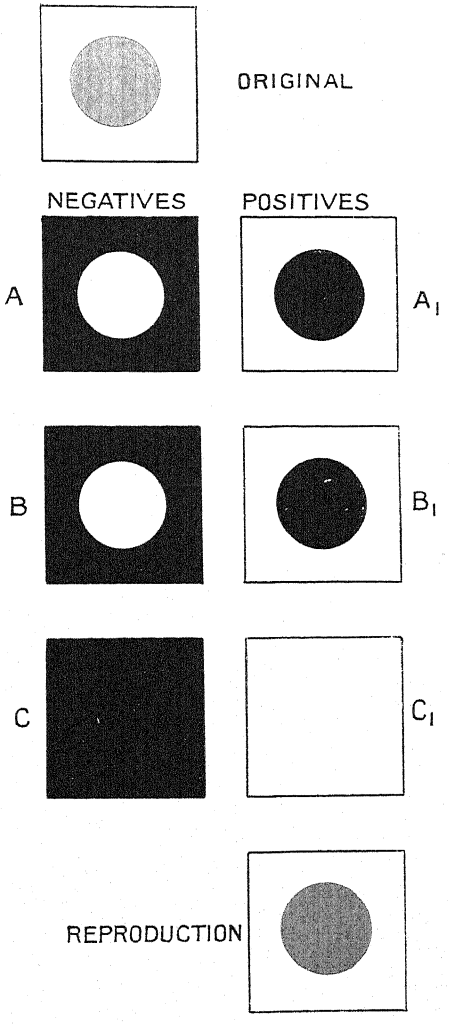
A third negative is taken through the red filter and would appear black all over, as in C, since the red light reflected from the card would also act upon the plate. If this were put into the lantern no light could pass at all. A positive C_1 is therefore made from the negative C.

If these positives are put into the lanterns, and the images are projected through the original filters on to the screen, we should get the correct reproduction of the original for the following reasons. A_1 would let blue-violet fall upon the screen on the outer square, but the circle being opaque would not transmit any light; B_1 would transmit green light to the outer square and none to the circle; C_1 would transmit red light to the outer square, and red to the circle also.

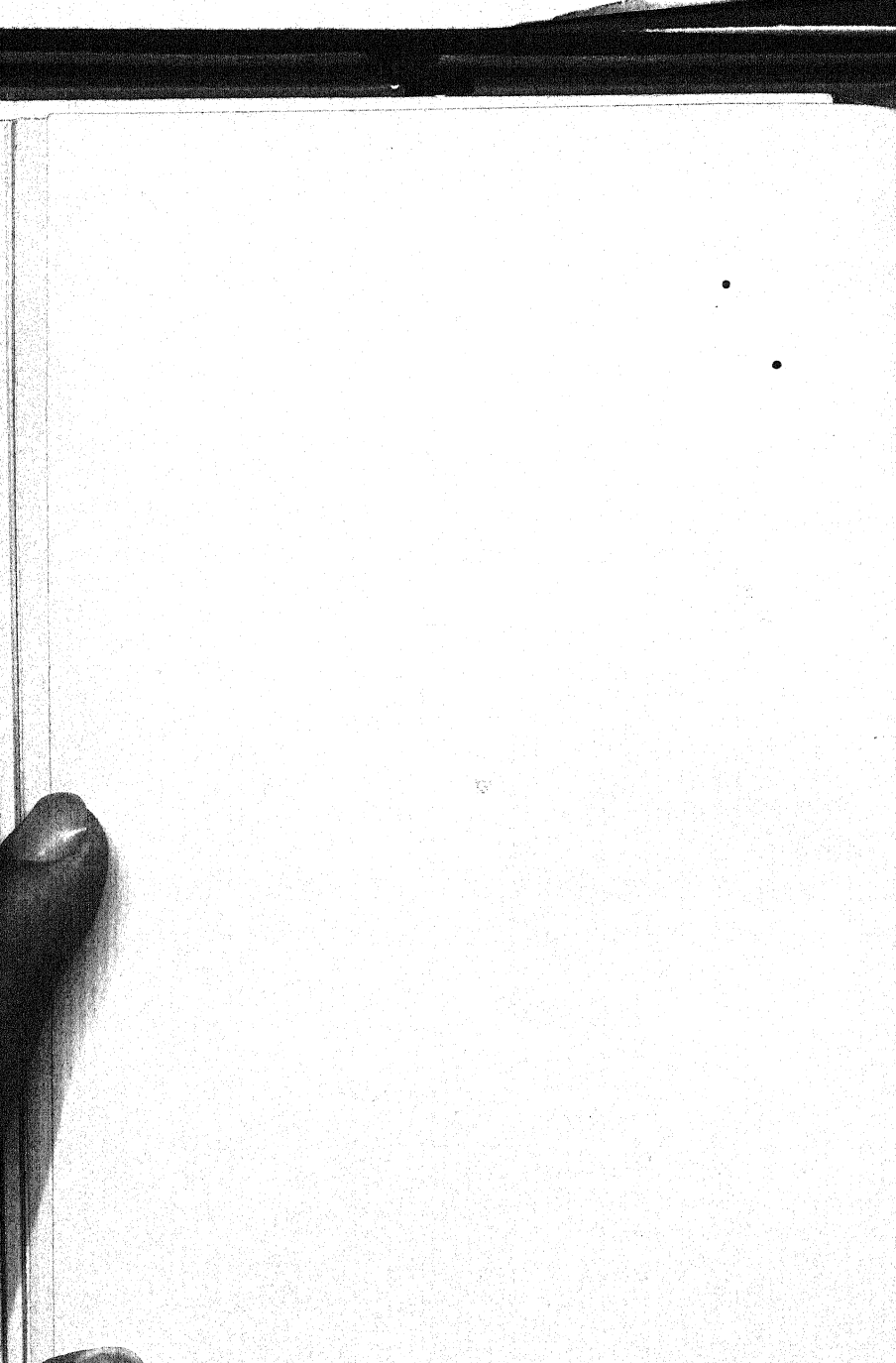
In describing how this explanation applies to the screen-plate processes (these get their name from the fact that filters are sometimes known as " screens "), we will take the case of a screen-plate (the Finlay) in which the screen is composed of tiny squares of red, blue-violet, and green in regular pattern too small to be seen with the naked eye. These squares are printed on a separate glass plate, sometimes called a mosaic screen, and this is put in close contact with the negative plate itself in the dark slide, the photograph being taken through these " filter " squares.

The negative taken through these, although to the eye like any ordinary negative, is actually made up of tiny squares of black, grey, and clear glass. The three negatives in diagrams A, B, and C are actually combined in this single negative which has been taken through this mosaic screen.

If this negative is put into register with the mosaic screen through which it was taken and held to the light, or put in a lantern, the outer square would appear black because all the colour squares of the screen would be covered by the corresponding squares of the negative, and would permit no light to pass through them. In the circle all the red dots would be covered (because in making the negative the light went



HOW THE COLOURS ARE FORMED
IN THE ADDITIVE PROCESS



through them); all the green and blue-violet squares would be clear glass since no light was transmitted. On our screen we should have the outer square in black and the circle blue-green.

A positive has therefore to be made from the negative, and when this is in register with the mosaic screen the effect is reversed. Light can now pass through all the minute squares on the outer portion of the film; this causes all three of our nerve fibrils to be excited equally (the dots are too small to be seen separately), and we see white upon the screen. In the circle the blue-violet and green squares are covered, and light passes through the red ones only, thus giving a correct reproduction of the original.

Subtractive Processes

We have next to consider the subtractive processes, in which the colours are produced in rather a different manner. As examples of the subtractive processes we have colour prints on paper, as well as all the various mechanical methods of three-colour photography, half-tone, colour gravure, and the like. Here the colours in the result are produced by using, not the colours of the filters through which the negatives are made, as in the screen-plate processes, but the colours that are complementary to them. By complementary in this instance we mean the other colours which, together with the one in question, form white light. For instance, in the experiment with the lanterns, it will be remembered that when we shut off the blue-violet light we saw yellow upon the screen; we therefore speak of yellow as being complementary to blue-violet, and make the print from blue filter negatives in yellow.

When the red light was cut off we had a mixture of blue and green on the screen; blue-green being the complement of red, the print from the red filter negative is made in a greenish-blue.

The mixture of blue and red make, as has been stated earlier, magenta, which is the complementary colour to green,

therefore our print from the green filter negative is printed in magenta.

That we *must* print in the complementary colours will be seen clearly when we come to consider the effect of making the negatives through the tricolour filters.

Filters and their Uses

We see then that filters may be described as the means employed to analyse the colours of the object photographed into their three components, in order that we may make negatives recording the respective amounts of each colour in the object. It is not necessary in a book of this nature to do more than explain in a general way what functions the filters perform; those who wish for further information should read Dr. Kenneth Mees' book, *The Photography of Coloured Objects.*

Obviously before the tricolour filters can be used in the way just described we must have plates which are sensitive to the colours which they transmit; we must therefore work with panchromatic plates, which are sensitive to all the colours of the spectrum.

The filters most generally employed nowadays are of two types. Those of the first type are made of sheet gelatine, dyed the appropriate colours, and are used as a rule by those who are making their first acquaintance with trichrome photography, and wish to find out its possibilities before indulging in the more expensive forms. Those of the second type are for more serious work, and are made with thin gelatine film cemented between two pieces of optically worked flat glass.

If filters of the second type are to be used on the lens, it is essential that the glass should be optically worked flats, or the optical qualities of the lens will in all probability be disturbed. If, however, they are to be employed immediately in front of the plates, then a good quality white glass free from blemishes will answer the purpose. If used in film form

they may be used either in front of, or behind the lens, as the thinness of the film does not seriously affect the optical system, but great care must be taken in handling them in that form as they are easily damaged.

Example Illustrating the Action of Filters

To illustrate the action of the filters by an actual example, we will imagine a photograph taken of a colour print of a pure red tulip, with green foliage, in a blue jar on a black table, as in the diagram opposite p. 18. It should be understood that in the diagram no attempt has been made to deal with any other than flat solid colours; half-tones and light and shade have been disregarded, except in the grey background, which has been inserted to emphasize the fact that a neutral grey such as this will be rendered alike in each negative and positive. Further, the explanation is not intended to be strictly scientific, but rather to give a broad idea of the formation of the colours. For instance, no account is taken of the fact that filters neither transmit nor absorb the light in the proportions that theory demands, and no consideration is given to the shortcomings of the pigments employed, in regard to their absorption and reflection of light. To include these matters would only tend to confuse the mind of the reader. Those desirous of more exact information should consult the work *Panchromatism*, by Messrs. Ilford, Ltd., or Dr. Mees' book mentioned above (p. 16).

Fig. 1 represents the colour print; A the blue-violet filter in front of the lens of the camera; B the negative after development. Note that the blue-violet filter transmits the blue light reflected from the jar, and the negative shows a black deposit of silver corresponding with the jar. No light is reflected from the table, and the filter absorbs the red light from the tulip and the green from the foliage, so that only the merest trace of these is seen on the plate; this mere trace (supposing the colours pure and the filters theoretically perfect) is due to the surface reflection of the incident white light. The grey

background reflects a certain amount of white light which is, of course, transmitted by the filter and records as a half-tone on the negative. Now in the subtractive processes the negative itself is not converted into a colour image but a positive from it is used to provide this; C is the positive, in which the effect, as one would expect, is reversed. Here we have a blank space corresponding with the jar, while the flower, the foliage, and table form a heavy black image. This is the case whether the printing in colour is to be done by mechanical means, and the positive is in the form of a block composed of squares and dots made by the half-tone screen, or whether the colour positive from it is made photographically as a dye or pigment image.

If we consider a moment we shall realize that it will be useless to print from this positive in the same colour as the filter; if we did so we should at the start have a blue-violet blossom; therefore, since the positive is the opposite of the negative we must print in the opposite, or more correctly, the complementary colour of the filter, in this instance yellow.

In fig. 2 we see the result of using the green filter E. F is the developed image on the negative, and since the filter transmits the green light from the foliage we have a black image of that, and a half-tone corresponding with the grey background, as in fig. 1, the remainder being white or clear glass, as the colours of these are absorbed by the filter. G shows the positive with these effects reversed, and H the colour positive in magenta, the colour complementary to the filter.

Fig. 3 shows the effect given by the red filter. In J, since only the red of the flower is passed in full, we only have that portion in full strength black, the remainder being as explained in fig. 2; K, the black-and-white positive; L, the image in blue-green, complementary to red of the filter.

We have now to consider the effect of combining the three images. Imagine the blue-green image to be superimposed over the yellow. The blue-green of the foliage will combine with the yellow to give the correct colour of green. The blue-

green jar will fit into the blank space of the yellow positive, while the yellow blossom will fit into the blank space in the blue image.

The question will naturally arise, why print yellow in the flower space? The reason of course is that we are going to superimpose there, not a pure red, but a magenta (a bluish-red), and the yellow is necessary in order to absorb the bluish part of that image from the light reflected back through it from the paper support, in order to give the pure red required.

So, too, with the amount of magenta in the jar. This is required to absorb the green that is present in the blue-green image, and so give the neutral blue of the original painting.

The full-strength portion of each colour positive in the table absorbs all the light falling upon it and gives the desired black, while the half-strength of the background in each, being of equal light-absorbing power, gives the neutral grey of the original.

It must be obvious, of course, that the foregoing explanations would only be absolutely accurate if the dyes in the filters and the colours of the printed images were theoretically correct in their absorption and transmission of light, and if also negatives and positives were of correct gradation. Unfortunately none of the dyes and pigments available conform exactly to these requirements, but improvements introduced in recent years have made it possible to obtain a very close approximation to truth in colour reproduction.

Those interested in fuller information on these matters should consult Wall's *History of Three-Colour Photography*, and Dr. Mees' *Photography of Coloured Objects*.

CHAPTER II

Exposure

Importance of Accurate Exposure

The exposure problem is the most important one confronting the colour photographer. Upon the correct determination of the exposure hangs the quality of the final result. More especially does this apply to the screen-plate processes of the combined type—the Autochrome and Agfa colour plates—for with these over-exposure can be as disastrous as under; and although with the other method of colour photography the great latitude of the modern dry plate can be taken advantage of, and errors if made in the direction of over-exposure are not specially serious, yet there can be no question that the finest technical results are to be obtained from plates to which the most nearly accurate exposure has been given.

It has to be remembered that not only has the quality of the light to be considered, but the nature of the subject—whether it is dark or light, near or far away from the camera—indeed, the correct classification of the subject is of equal importance with the actual value of the light.

When dealing with a subject consisting of masses varying very much in their relative darkness, the worker must make up his mind as to which portion of the scene is most important, and the exposure should then be based upon the time required to give the necessary detail in that particular part.

Light Measuring Meters

When the light is being measured by one or other of the light measuring meters, as opposed to the calculators, it is often a good plan to measure the intensity of the light in the lightest portion, say, for instance, the sky when it is desired to retain some beautiful cloud formation, and then

to measure that in the darkest portion in which detail is required, and to give an exposure which is a compromise between the two. This advice applies more to the transparency worker than to the maker of colour prints; to the latter the advice is to expose for shadow detail.

Calculators

The system embodied in the calculator method of arriving at exposure largely depends for its success upon classification of the subject under the headings given by the makers of the instrument. This is not always an easy matter to decide upon; one so often comes across a subject, especially in landscape work, which does not seem to fit under any of the headings given. The thing to do is to endeavour to arrange the amount of light and shade in the masses, and the distance from the camera, in the mind's eye, and to mentally appraise it so that one can say, " Well, it isn't so and so, or so and so, but I imagine it presents about the same amount of shadow and high-light as so and so."

In the Burroughs and Welcome Calculator and Diary there is an excellent series of photographs illustrating the various classifications of subject.

Choice of Meter

As to the best type of meter to use, this is largely a matter of personal taste, and it is difficult to express an opinion as to which is the most suitable. The writer has used most kinds with success. The important thing is to try the type which, for one reason or another, appeals to one, and then to stick to it until its peculiarities are thoroughly mastered, when it will be found that one can get satisfactory results with almost any type. Personally, the writer has of late found the extinction type of meter, of which the Justophot is an excellent example, of very great value, more particularly because of the wide range of subjects embraced by it, since objects illuminated by artificial light can be dealt with as easily as

those lighted by daylight. Some workers view the extinction meter with disfavour because the personal factor of one's eyesight enters so much into the conclusions as to the exposure arrived at by its aid; but here again it is a question of getting used to the particular type, and making the necessary allowances for one's own eyesight.

Certainly the Justophot has in the author's hands been invaluable in arriving at the correct exposure in cases where previous experience was of no assistance, and in which it would have been impossible to get a tint with a tint type of meter, as for instance in photographing illuminated transparencies, and in many cases where artificial light was the illuminant. Then, too, the exposure calculator, such as the one to be found at the back of the Burroughs and Welcome Photographic Diary, is most useful, and for many years was the sole means used for arriving at the correct exposure; that too proved invaluable.

On the other hand, other workers declare that only those meters which actually measure the actinic value of the light can be depended upon. Thus, for example, the makers of the Watkins Bee meter issue a special dial for use with the screen-plate processes. They maintain that the usual laws, regarding the increase of exposure necessitated by diminishing the aperture of the lens, do not apply to the screen-plate processes. They have accordingly worked out a special dial for these plates, and this should be inserted in the instrument instead of the standard dial issued for monochrome work.

The recently introduced photo-electric cell meters, whose name is legion, should be of immense value to the colour worker, since they measure the light reflected *from* the object photographed and not merely the light falling upon it. They, like the other forms of meters need to be used with common sense and discretion; care, for example, must be taken to avoid the light from the sky, when used out of doors, or that streaming in through a side window, from exerting an undue influence upon the cell. Remember you want to measure

the light reflected *from* the subject, not that striking slantwise upon the window of the cell. Therefore under such conditions screen the aperture with hand or hat, just as one uses a lens hood to screen the lens of the camera. If this is not done, your results will be under exposed.

Don't forget also that the photographic material varies in speed occasionally, and when beginning to use one of these meters take especial care at the start to note how the readings compare with known correct exposures under similar circumstances, and modify, if necessary, the speed factor or plate group number or classification until it agrees with that result, and then one can rely upon the readings with confidence.

Exposure for Shadow Detail

With reference to negatives for colour work on paper, the advice given for monochrome photography of exposing for shadow detail holds good. It *is* possible to deal with a plate upon which some light action has taken place, but it is obviously impossible to improve, by any amount of intensification, detail which is not upon the plate at all; therefore under-exposure is always to be avoided.

Small Stops and Brilliancy

Some workers have stated that it is impossible to get brilliant colours if small stops are used, whether in transparency or in colour prints. This has not been the experience of the writer, who finds it difficult to imagine any possible reason for such a result, provided a *sufficient* increase of exposure is given. This should, in these cases, be considerably in excess of the exposure given for equally small stops when used for monochrome work. Not less than double the indicated exposure should be given if stops smaller than F. 32 are used, since the inertia of the emulsion has to be overcome before the light action begins to take effect. The filters probably exert a damping effect here, which has to be taken into account. Provided, however, this is done, there

should be no difficulty in obtaining brilliant colours in the result when small stops are used.

Advantages of Small Stops with Long Exposures

The use of a very small stop, say F. 44, and a long exposure, which may run into anything from 10 minutes to half an hour, according to lighting conditions, provides an excellent way of dealing with the difficulty of persons moving across the field of view. As an instance of this, the writer exposed an Agfa plate for 12 minutes at F. 44, when taking a view of the Kursaal at Interlaken, and except for a couple of inquisitive people who stood watching for 5 minutes to see when the fool of a photographer was going to start taking the picture, no sign at all is to be seen of the throngs of people passing to and fro continuously in front of the camera. Of the inquisitive ones there is but a ghost, the reason of course being, that since 12 minutes' exposure was necessary to produce a properly exposed plate, obviously those who were only in front of it for a minute or so, would not be there long enough to make any impression. Further, such exposures help to get over the difficulty of occasional movement of flowers, &c. Many a time has the author taken advantage of this, to get both a picture and a rest, when photographing in Kew Gardens in the evening. On these occasions he has frequently given exposures running to half an hour, and thereby secured pictures which were both colourful and brilliant.

CHAPTER III

The Subtractive Processes
Trichrome Carbro: Duxochrome

MAKING THE NEGATIVES

The general principles underlying the subtractive process in colour photography have been explained at p. 15, where also an example was given to illustrate the action of filters. We have now to consider the method in detail.

Although it is possible to produce the three-colour separation negatives by a single exposure, either in a one-exposure tricolour camera, or by means of a film tri-pack (three films in intimate contact one behind the other, with the necessary means of colour separation incorporated), neither method is at present readily available. The cameras in question are extremely costly, owing to the delicate adjustments necessary to overcome the inherent difficulties of obtaining three identical images simultaneously; and for many reasons they cannot be regarded as being altogether satisfactory in use.

Those, therefore, who wish to attempt colour photography on paper must be content to make their colour separation negatives one after another. If this be done by means of separate plates (or films), thus necessitating the changing of the filter as well as of the plate or film for each exposure, the field of work is somewhat limited. The time required to make the changes puts any work where movement is likely to take place, as in portraiture, out of the question; but for still-life subjects, copying paintings, or similar work, the exposures can be made in this manner.

The first essential is a camera upon a good firm stand; rigidity is essential.

For first attempts the gelatine type of filter is quite suitable

if it is used with care. Gelatine filters may be procured at a trifling cost from the makers of the panchromatic plates or films which it is intended to use. It is advisable to use filter and plate of one make and to avoid " ringing the changes " upon them, since the possibility of error is introduced by so doing. If filters in this form are to be used on the lens (as is best), some kind of holder is necessary, since they are easily damaged by moisture from the fingers when handling them.

One method is to use three pill boxes which will slip on to the lens mount; the bottoms are taken out of these, and the gelatine films carefully stuck on in their place.

Perhaps the best way is to mount the filters side by side between two pieces of card, with square or circular apertures cut in them, as shown at A, fig. 1. The combination slides through the holder B, which is slipped on to the lens mount. Holders of this type can be made of tin, or thin brass, or even cardboard, by the handy man; or those on the market for use with ordinary filters will answer admirably, provided the card can be slipped through.

Method of Making Cardboard Filter Holder

In making this holder, the two sides should be cut from fairly stiff card, and the apertures cut in them large enough to permit the full aperture of the lens to be used. They should be stuck together with a piece of lantern-slide binding tape, as shown in sketch.

The squares of gelatine film, which should not be handled with the fingers, but lifted from the paper wrapping with tweezers or a small pair of scissors, should be laid over the apertures on the lower card, and held in position with a smear of seccotine. They should be mounted in the order shown, i.e. alphabetically, as one is then unlikely to get muddled; and the two cards should be folded together and bound round the edges with binding tape.

The cards should be blackened, and if they fit loosely in

the outer holder, black velvet ribbon, as shown, should be stuck round them. White marks should be painted on the back of the card, so that it may be possible to see when each filter is centred in front of the lens, without coming to the front of the camera.

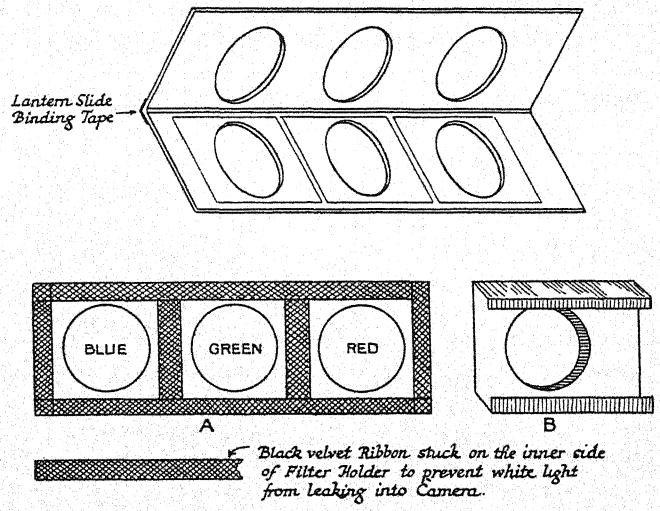


Fig. 1—Filter Holder

The Kind of Plate to Use

The plates or films used *must* be panchromatic. If plates are chosen, it is almost as essential that they should be backed, halation being fatal to success in colour photography. Although these plates *may* be used with a green safe-light, it is not at all difficult to load and unload the dark slide in total darkness, and it is certainly preferable to do so. Panchromatic plates are packed in pairs face to face, and the backing can usually be detected by the sense of touch, as it is slightly less smooth than the emulsion.

Loading the Dark Slides

When loading the dark slides it is advisable to avoid, if possible, taking the plates to complete a set of three from different boxes, unless the batch number is the same, since although every care is exercised by the makers to keep the emulsions of various batches constant as regards speed and colour sensitiveness, these may vary slightly. If one is at the end of a box, it is better to leave an odd plate or two, to be used for monochrome work, and take the three for the tri-colour exposure from a fresh box, rather than run the risk of the two boxes varying to any considerable extent in either of the qualities mentioned, and so upsetting the balance of the set of negatives. When one is buying several boxes at a time it is best to ask for them all of one batch; and as every batch is numbered on the box, it is easy to see whether the plates from two boxes can be used together.

Choice of Subject for Exposure

As a subject for the first exposure nothing is better than still life or a simple flower study. A wedge should be placed close to the objects in such a way that it is photographed and appears on the negative, but can be trimmed off the prints without spoiling the picture. A wedge, by the way, may consist of a strip of bromide paper printed in a series of steps ranging from black at one end through greys of diminishing strength to white at the other. Ready-made strips can be got from the Autotype Company. The reason for using the wedge will be explained later.

After the subject has been arranged and focussed, everything must be screwed up tightly so that there is no fear of movement either of stand or camera. The exposure should be determined by means of an exposure meter (see Chap. II).

Although the modern panchromatic plate possesses quite enormous latitude, it is obviously desirable to have the negatives correctly exposed. The correct exposure having been determined, it is multiplied by the filter factors for the

respective filters; these factors are given in a leaflet enclosed in the box of plates or films.

Filter Factors and Exposure

The factor numbers given by the manufacturers vary according to the make of plate and the actual batch of emulsion, but with the standard filters in general use they will be found to be about 4–5 for the blue, 10–12 for the green, and 7–8 for the red. (The figures given apply to daylight; artificial light factors differ considerably from these, and are to be obtained on request from the manufacturers.) This means that if the normal or unit exposure already calculated is one second, then the plate exposed through the blue filter must receive 4–5 seconds, the green filter plate 10–12 seconds, and the red 7–8 seconds.

There are now two distinct types of Panchromatic emulsions; in one the blue filter has the lowest factor for daylight, in the other, the red, so care must be taken to note to which class the material in use belongs.

In making the exposures, the three plates are exposed in turn, care being taken to change the filter as well as the plate, and to give each plate its correct exposure according to its filter. Forgetfulness of any of these points can only be remedied by making a fresh exposure on another plate. Care must be taken when withdrawing the shutter of the dark slides not to move the camera; if these work stiffly they should be made to slide freely by rubbing the edges with a little black lead.

Developing the Plates

When the exposures have been made, the next operation is development. Here again one is restricted to working either in complete darkness, or in the dim light of a green safe-light, unless a desensitizer is used. This latter procedure is strongly recommended, and there are several excellent desensitizers on the market. They may be used as an addition to the developer, but the better way is to have a separate dish considerably

larger than the plate to be used, and to put a fairly liberal amount of desensitizer in it. A second dish with the developer recommended by the plate-maker should be placed near the first. It is advisable to use the formulæ given by the makers, as they also give time and temperature tables to be used in conjunction with the formulæ. These should be referred to, and the time which they give, corresponding to the temperature at which development is to be carried out, should be noted.

Development should not be carried too far, as excessive contrast should be avoided.

If the worker has a marked preference for any particular developer, it may be employed, for any well-balanced developer is suitable; but the time and temperature method of development is preferable to any method of inspection, so that unless these particulars are available, it is better to use the maker's formulæ.

When separate negatives are being developed it is advisable to prolong the development of the blue filter negative to about half as long again as the other two, for the reason that the blue filter has the effect of producing a softer negative, the shorter light rays appear to scatter more easily in the emulsion, and a negative of definitely less contrast than the red and green negatives is the result unless development has been prolonged.

The increase necessary varies with different batches of emulsion and may sometimes be 80 per cent longer if equal contrast is to be secured in all three negatives. If this is not done, however, and with negatives on one plate taken with a repeating back it cannot be, then equality of contrast is secured at a later stage, as will be described in the chapters on the Trichrome Carbro process.

The reason this equality of contrast is necessary can be appreciated if the use of the step wedge is understood. It is the purpose of this wedge to indicate whether the contrast of the three negatives is similar, it being very difficult to

judge by the general appearance of the negatives, so much depending upon the character of the subject. As an instance —if an old oil painting, dark and yellow with age, is copied, properly exposed and developed negatives look very unlike in general appearance. In all probability the blue filter negative will look but a ghost beside the other two, despite correct exposure and development; which the wedge, if present, will indicate. This is as it should be, because a full strength yellow positive will be required to render such a subject, and to give this the negative will appear thin compared with the others. The wedge, however, will under these circumstances appear of equal strength and contrast to those on the other negatives, since *it* is not yellow with age. Lacking a wedge, the beginner would suppose the negative to be both under-exposed and under-developed, but with the wedge he can see at once that this is not so.

Taking the wedge as a guide, it will be apparent that if in one negative it is of less contrast than in another, the reproduction of it will suffer accordingly. If in the blue filter negative it lacks contrast, then the deeper steps in the yellow image will not be strong enough and, in the combined result, the darker tones will be of a purplish shade. By prolonging development of this negative, or by the method described in pp. 38, 39, this can be corrected and the proper balance attained, and a correct representation of the colour, not only of the wedge, but the whole subject, is secured.

A third dish with an acid-fixing bath is placed in readiness.

Desensitizing the Plates

The dark-room light is turned out, the first plate is removed from the dark slide and slid face upwards into the desensitizer in total darkness, and the dish is rocked in both directions and covered with a card. The dark-room light (a bright orange light may be used) may now be turned on and the time noted.

At the expiration of the time given for the desensitizer in use (one or two minutes) the plate is taken out and slipped

into the dish containing the developer. This dish should also be covered with the card, as it is inadvisable to expose the plate unnecessarily to the light even when using a desensitizer. The dish should be rocked in both directions to avoid markings on the plate, for the time given on the development card. The plate is then given a brief rinse in water and put into the fixing bath. Fixation should be complete in about twice the time taken for white emulsion to disappear.

The backing on the plate can be ignored until the washing of the plate is completed, when it should be removed with a tuft of cotton wool before setting the plate aside to dry. It is advisable to gently swab the emulsion side of the plate with cotton wool under the running tap in order to get a perfectly clean surface.

The desensitizer should be filtered occasionally to remove any particles of emulsion or other foreign matter.

The Repeating Back

A useful piece of apparatus which is very popular with three-colour workers is the Repeating Back. This is a piece of apparatus designed to fit upon the back of any camera which can be fitted to a stand, from one taking a $3\frac{1}{2}$ by $2\frac{1}{2}$ in. plate up to whole-plate size or larger. It consists of three parts. The first part is a long frame, having a central rectangular opening corresponding in size with the negative required; attached to this frame is a fitting identical in size with the ordinary focussing-screen holder of the camera, for which it is substituted. The second part is a focussing-screen, which slides in grooves at the top and bottom of the long frame, and is used for focussing in place of the screen belonging to the camera. The third portion, which is made to slide in the same grooves, is fitted with three colour filters fixed side by side. It carries behind these the dark slide, containing a long narrow plate on which the three exposures are made side by side. On the lower edge of the Back a spring catch is fitted, which goes into slots in a brass strip on the sliding

portion, and which ensures accurate centring of the plate and filters, behind the rectangular opening in the Back itself.

To use this piece of apparatus the ordinary focussing-screen is removed, and the Back with the small focussing-screen in position is put into its place. If the picture is to be a horizontal one (i.e. with the longest side horizontal) the Back is used vertically—if the picture is a vertical one the Back is used horizontally.

The picture is focussed in the usual manner, the focussing-screen removed and the sliding portion containing the dark slide inserted in the grooves. The lens shutter is then closed, and the sheath of the dark slide withdrawn. The Back is now ready to make the first exposure. This being given, the catch is depressed and the sliding portion moved along until the catch engages in the next slot on the holder. The second exposure is then given, and the operation is repeated for the third. The sheath of the dark slide must be replaced before removing the dark slide from the holder, otherwise, of course, the plate will be fogged.

It will be appreciated how much more rapidly the three exposures can be made with this piece of apparatus than with separate plates, filters, and dark slides, or even than with roll films or film packs, since these also entail a separate operation to change them.

The Repeating Back can really be regarded as a *sine qua non* to all who intend taking up three-colour photography at all seriously, for besides possessing the advantages enumerated above, it is more economical in many ways—it needs only one plate instead of three, and it does away with the costly optically flat filters which are almost essential if permanent filters for use on the lens are required. Further, it simplifies the operations of developing, fixing, and the making of enlarged prints, while its use eliminates the snag which may arise from variations in the emulsions of different boxes of plates. Indeed, if three-colour photography were deprived of the aid of such a fitting, and had to depend solely on the

orthodox method of plate and filter changing, it is to be feared that its scope would become so limited, and the number of operations so many and varied, that any but the most enthusiastic amateur would have his enthusiasm damped and his interest stifled at the start. The initial cost of the Repeating Back, not in itself a great one, is well repaid in every way.

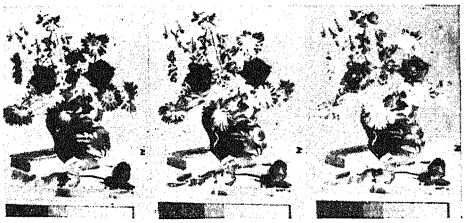
For the professional photographer the Vivex automatic repeating back of Messrs. Colour Photographs, Ltd., permits successful portraiture, since all three exposures can be made within 2 seconds.

So much for the preparation of the three-colour separation negatives.

TRICHROME CARBRO

Three-colour Carbro, or Trichrome Carbro, as it is usually called, is, like its monochrome namesake, based upon the production of a pigmented gelatine image from a black-and-white bromide print. It is an extremely fascinating process to work, and after the bromide prints have been prepared—these by the way may be used several times—the whole process can be carried out in daylight. The formation of the image is not due to the action of light, but to a chemical reaction which takes place between the silver image of the bromide print (i.e. the black and grey parts of the picture) and the soluble gelatine coating of the Carbro tissue in which the pigment is incorporated.

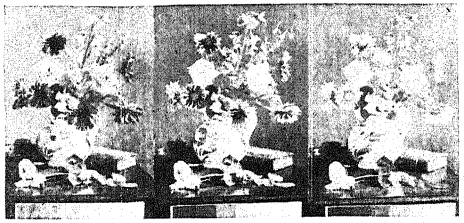
The Carbro tissue, which is sensitized at the moment of use, is brought into contact with the bromide print, and the silver image immediately commences to render the gelatine of the tissue insoluble. It does this in exact proportion to its own depth of deposit, so that where there is a very black portion in the picture, a very strong degree of insolubility is produced; where there is less silver, as in the grey portions, correspondingly less strong action takes place; and in the white parts, no action occurs in the tissue.



Red Filter Negative

Green Filter Negative

Blue Filter Negative



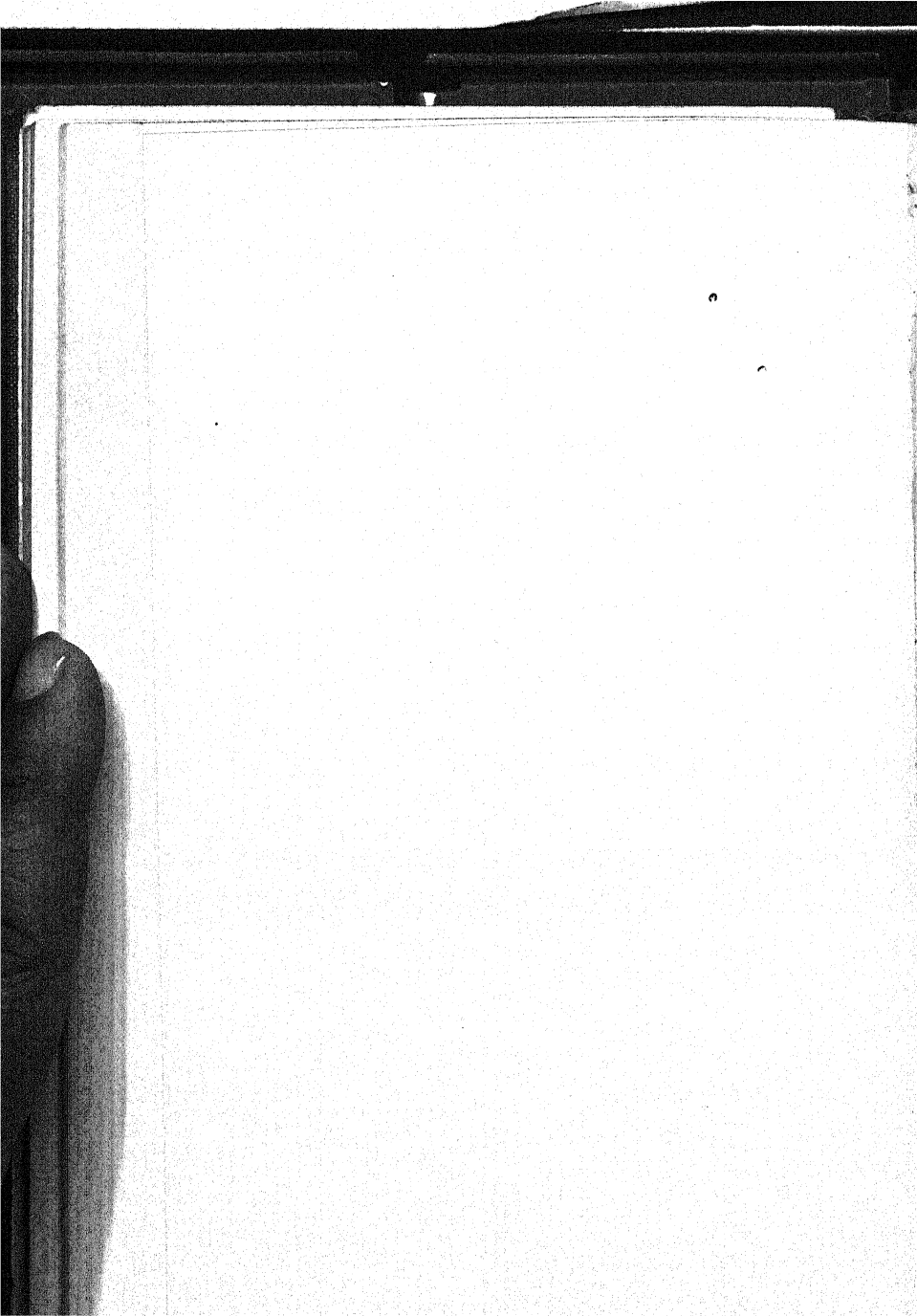
The Positives

Bromide for Blue Positive
(Exposure, 15 seconds)

Bromide for Magenta Positive
(Exposure, 15 seconds)

Bromide for Yellow Positive
(Exposure, 18 seconds)

THE CARBRO PROCESS ILLUSTR ED (I)



The Carbro tissue is then removed from the bromide print, squeegeed upon a support, and later put into hot water. The gelatine which has not been made insoluble (insolubilized) dissolves, the paper backing is stripped off and thrown away, and gradually there appears upon the support an exact reproduction of the bromide print, but in the colour chosen instead of in the black-and-white of the original print. When wet the image can be seen in high relief, the dense shadows being thick and swollen, the half-tones less thick, and the white high-lights quite clear and free from deposit.

This description refers to the reproduction of a bromide print in monochrome, but it applies equally to three-colour reproduction, except that in that case, instead of one bromide print, three are used, one from each of the colour separation negatives. The colours used, as explained earlier (p. 12) are complementary to the filters through which the negatives are taken, i.e. the bromide print from the blue-violet negative is reproduced in yellow, the one from the green in magenta, that from the red in blue-green Carbro tissue (see Plate, p. 34).

Before going into the actual details of the reproduction of these Carbro positives, it will be advisable to emphasize the necessity of making the best bromide prints the negatives are capable of yielding. From the outline given of the process it is easy to appreciate how very important a part the bromide print plays. The slightest veiling of a high-light, whether it is wanted or not, will produce a corresponding deposit of colour in the Carbro positive made from it. Hence it is of vital importance to avoid any unwanted veiling of the bromide print, whether it be due to over-exposure or to working with an unsafe dark-room light.

Let it be supposed that a portrait has been taken of a man with a stiff white collar, the highest light of which should be white. If one of the bromides is slightly veiled over at this spot, to an extent possibly immaterial in a black-and-white print, it may well matter very much in colour Carbro, for there would be a tint of colour instead of a white high-light in

the finished print. Therefore, every care must be taken in making the bromide prints, for if these are faulty it is useless to expect a first-class result.

When purchasing the bromide paper for making trichrome prints, it is advisable to buy it in the roll. It is slightly cheaper to do so, but more important is the fact that paper when wetted expands more in one direction than in the other. In packets, the bromide paper is cut in the way in which most waste is avoided, and one cannot be certain that all pieces have been cut in the same direction. Consequently, one may produce three perfectly good colour positives and then find that, owing to neglect of this precaution, it is impossible to get accurate registration. The bromide paper may be procured in rolls 8 in. wide and 10 or 25 ft. long. These will cut into pieces 8 × 6 in. or 10 × 8 in., which are convenient sizes for enlarging. The time taken by the process warrants the slight extra expense involved in working in these sizes in preference to smaller.

If care is taken in the exposure of the negatives, and their development is carefully standardized, a single type of bromide paper may be found sufficient, that with a smooth, not glossy, surface and giving normal contrast, for a reasonable amount of control of contrast is possible when making the Carbro positives; but occasionally it may be necessary to use a paper giving softer or more " contrasty " results than the normal, in order to get the desired quality in the bromide print. It should be added that it is seldom possible to " ring the changes " on the variety of the paper in any one set of prints, as very often the paper base itself varies and expands differently, preventing registration.

The Bromide Prints

When the three negatives are separate ones and have received the differential development described on p. 30, one developer—amidol, metol-quinol, or any of the well-known proprietary developers may be used for the bromide prints,

since the desired equality of contrast will have been secured in the negatives themselves. When, however, this has not happened, as when a repeating back has been used and the three negatives are all on one plate, then the balancing of the contrast must be done when developing the bromides. For this, two developers are necessary, one giving a "soft" result (plain metol) and this is used with the red and green filter negatives, and the other giving contrasty or "hard" results (hydroquinone-metol) for use with the blue filter negative. It may be pointed out that quite excellent results can be obtained even if only one developer is used, and the increase of contrast secured by treatment of the Carbro tissue as is described later, but when great accuracy in the reproduction of the colours is required, then the use of the two developers is well worth the little extra trouble involved.

The formulæ for these developers are as follows:

Plain Metol Developer for Soft Results

	Metol	150 grains	8½ grammes
	Sodium sulphite (anhydrous) ..	1¼ oz.	30 ,,
or	Sodium sulphite crystals ..	2½ ,,	60 ,,
	Sodium carbonate (anhydrous) ..	1½ ,,	37 ,,
or	Sodium carbonate crystals ..	4 ,,	100 ,,
	Water to	40 ,,	1000 c.c.

To use take developer 1 part, water 2 parts, develop for 2 minutes at 65° F. (18° C.).

Hydroquinone-Metol for Contrasty Results

	Hydroquinone	150 grains	10 grammes
	Metol	8 ,,	½ ,,
	Sodium sulphite (anhydrous)	1 oz. 55 ,,	36 ,,
or	Sodium sulphite crystals ..	2¼ oz.	72 ,,
	Sodium carbonate (anhydrous)	1 oz. 280 grains	54 ,,
or	Sodium carbonate crystals ..	4¼ oz.	140 ,,
	Potassium bromide	40 grains	3 ,,
	Water to	30 oz.	1000 c.c.

To use take developer 1 part, water 2 parts, develop for 3 minutes at 65° F. (18° C.).

Use a freshly prepared acid fixing bath.

Beginning Operations

First of all, after cleaning the backs of the negatives, getting the bench ready and measuring out the developer (the Metol developer will serve for this first part of the procedure), a contact print must be made from the three negatives so that it may be seen whether any adjustment of contrast in making the bromides will be required. This should be done whether the negatives *have* been balanced or not, as one has to consider not only equality of contrast, but correct balance of strength of each. When possible use a set of negatives having the step wedge in them (plate facing p. 34).

Test Exposure to Determine Balance of Contrast

It is most important that these contact prints shall receive precisely the same exposure and development, or it will not be possible to obtain the desired information from them, and if separate negatives are used they must all be exposed together in one large frame or great care taken to see that exposure and development of all three are identical.

A reasonably correct exposure should be given, i.e. over exposure, and shortened development particularly, should be avoided, as it tends to flatten all three prints and make it difficult to determine the correction required. As soon as the contact prints are fixed they should be examined carefully in white light. If the three negatives have each received correct exposure and properly varied development, then the step wedges in each print should be alike. Both the strength, or depth, *and* the contrast will be identical. If this is the case, then it indicates that in making the enlarged bromides from which the Trichrome Carbro prints are to be made, the same exposure and development may be given to each, and only one developer, that which will give the best bromide print as judged by the ordinary monochrome standard, will be needed.

This, unfortunately, seldom occurs, and more usually there

will be found a difference either in strength or in contrast (or in both) in one or other of the prints.

When the contrast of the wedge is alike in each, only one developer is required and it may be either the Metol, or the Hydroquinone-Metol, or a mixture of both according as the negatives are of hard, normal, or soft-contrast themselves.

The only adjustment necessary in this case lies in exposure, and the negative which yields a darker wedge than the others will of course need a shorter exposure to balance matters when the enlarged print is made, and vice versa if the opposite is the case. Should, however, it be the contrast which needs correction, this is done by development.

As stated earlier, almost invariably (unless correction has been applied to the negative) the print from the blue filter negative will show less contrast than the others. That is to say, if the white end of the step wedge is white, then the black end will only be a dark grey instead of black as in the others. If the Trichrome Carbros were made from bromides like this, then the black end of the wedge would lack yellow and be purplish in colour, and other colours in the picture would suffer to a greater or lesser degree.

In speaking of " enlarged " prints from which the Carbro images will be made, we do so for the sake of clarity; actually either contact or enlargements or reductions may be used, but usually, in view of the time taken in the production of the result, an enlargement seems to make the time spent more worth while.

Bromides

The contact prints being made, the next part of the procedure is to determine the proper exposure for the large prints. Here it should be remarked that whether enlarged or contact prints are to be used for the Carbros, it is essential that they have a narrow white margin at least an eighth of an inch (3 mm.) round, otherwise frilling will result when developing the Carbro images. In the case of contact prints, the rebate

of the printing frame will provide this; in enlargements a cardboard or other mask must be used to ensure a white edge.

For those who have an enlarger big enough to cover all three negatives at once for projection, it must be pointed out that it is not permissible to do so, as there will be slight differences in size, and exact registration of the Carbro images will not be possible.

For this reason and to avoid any possibility of one negative being lighted slightly differently from another (for evenness of illumination is not always a *sine qua non* even in the best regulated and most expensive enlargers), each negative should occupy as nearly as possible the same position in the enlarger.

From which Negatives are the Different Colour Images made?

The colour positives are made in the colour which is complementary to the filter through which the negative was taken:

From the red filter negative the blue positive is made.

From the green filter negative the pink (magenta), and from the blue filter negative, the yellow image is made.

Making the Enlarged Bromide Prints

In determining the correct exposure it is best to begin with the red filter negative, from which ultimately the blue Carbro image will be made. This is because one is more easily able to judge just how deeply it should be printed.

It is not necessary in making the test exposures to make a full size print, but the portion chosen should include if possible the wedge and the " highest light " in the picture.

In a landscape with a blue sky and white clouds, the clouds should be included; in a portrait the face and if present, a white collar or light part of a dress; in still life and flower studies the lightest object, a china bowl or a white or pale yellow rose—as giving to the beginner the easiest clue to what is wanted.

An exposure to this part is given in steps, beginning by exposing the whole piece for say 10 seconds, then covering a portion and giving another 10, covering more and exposing again and so on until the whole strip has been exposed.

It is then put in the developer chosen (normally the plain metol developer) and developed for 2 minutes at 65° F. (18° C.). If warmer the time may be shortened to say 1½ minutes, and colder to say 3 minutes; but temperature should not be allowed to fall below 60° F. (16° C.), particularly with the hydroquinone metol developer. Below 58° F. (14° C.) the hydroquinone becomes inert.

Temperature Control when Developing in Cold Weather

Much trouble is avoided if developer temperatures are kept even, and a warming box containing a couple of " Strip-lite " electric lamps, and having a metal top, will keep the temperature at a steady 65° (18° C.) if used with intelligence. This box should be about 3 ft. × 18 in. and 6 in. deep, with a watertight metal top and a removable bottom, so that lamps may be changed when required. The electric fittings should be fitted by a qualified electrician, who should be informed of the purpose to which it will be put, so that he may take proper precautions to avoid " shorts ", as the sometimes wet condition of the dark room floor makes a home-made contrivance liable to give the worker a dangerous shock. This heater serves equally well in cold weather for developing the negatives, which are even more sensitive to changes of temperature.

A Method of Making Test Exposures

Another and rather better method of making test exposures is to make a cardboard device as shown in fig. 2. This is pinned by the two outer pins on the enlarging table or easel, so that the opening comes where the high light portion described above will be projected. The light in the enlarger is switched off, and a square of bromide paper just large enough to project beyond the cardboard as shown is

inserted, and a pin stuck through the hole in the centre. The first exposure is given, a pencil line drawn to show the side of the quadrant and the paper twisted round until the pencil line disappears under the protecting card, and the second and increased exposure given; the operation is repeated until all four segments of the bromide paper have been exposed with progressively increasing exposures.

The paper is developed and fixed and then examined carefully.

The reason this method of making the test is superior to the other, is because the same portion of the print is in each

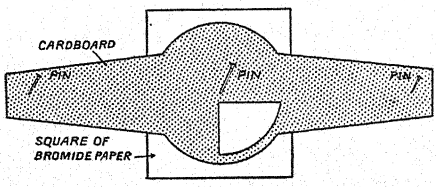


Fig. 2

exposure, instead of a different part for each of the exposures, and this helps considerably when making the comparison.

The Standard by which the Exposure is Judged

To understand by what standard one must judge, imagine that it is a portrait of a child which is being printed. Obviously very little blue would be wanted in the delicate colouring of a child's complexion, and the correct exposure is one which just gives, *and only* just gives a faint general image, sufficient to give modelling to the face. If printed too deeply then the finished result would be muddy in tone, and if insufficient exposure is given the face would be an unpleasant pinky yellow, since, as is generally known, there is more yellow and pink than blue in a flesh tone, but sufficient blue *must* be there or the effect will be definitely wrong.

If there is anything quite definitely white such as a white collar in the picture, then even here only the highest lights,

such as the line of high light on a stiff collar, or the wrinkles on a soft one, should be quite white in the bromide print.

Although the beginner is not likely to commence with a portrait, it has been given as an example, since it will be easy to comprehend the underlying idea, but it must be borne in mind that complexions differ in the amount of blue required, and the sun-tanned and wrinkled visage of an old seaman will require a much stronger blue image than that of the child cited above. If a flower study (such as that shown facing p. 44), is chosen, then the test portion should include the creamy white roses, the amount of blue required to give modelling being shown in top left print, and again in the reproductions of the bromides in illustrations facing p. 34.

(Note: The times in No. 2. Carbro bath shown in the former will be dealt with in due course.)

The chosen exposure is now given to the enlarged print and *after* exposure and before developing it should be marked B, and the exposure and developer to be used marked on it for future reference. It is then developed and fixed. Next refer to the contact prints, and if the wedge is alike in each, then the exposure for the red print (from the green filter negative) will be the same as for the blue one; if the wedge is lighter, then the exposure will be more, and if darker, less. It is best to make a test exposure of the enlarged wedge to make sure the proper exposure is given the whole print, which is then exposed, marked with an R, and with the other data mentioned, developed and fixed, the same developer being used as for the blue bromide.

The Amount of Developer to Use, and Method of Use

It will be found advisable to use enough developer to well cover the bromide paper, but to use it only for one set of prints. It may be poured into a bottle after use, and then, if used within a day or so, may be used to redevelop the bromides after the Carbros have been made from them. This is better practice than using a larger quantity of developer and using

it to the point of partial exhaustion. Incidentally, the bromide paper should not be immersed in water first, it being difficult to avoid markings; instead it should be passed quickly through the developer, emulsion side down, turned over, and the surface thoroughly swabbed over with a large tuft of cotton wool kept in the dish of developer for that purpose.

The yellow bromide now remains to be made; if correctly balanced negatives are being used, and the wedge in the contact print is identical with the other, then the procedure and developer already mentioned is used.

Securing Equal Contrast for Yellow Print

If, however, the wedge is flatter than the others, the hydroquinone-metol developer should be used.

A test exposure of the enlarged wedge is made as before and this is developed for the longer time necessary for this developer (3 minutes at 65° F. (18° C.), when it will be found that the contrast of the wedge will now equal, or practically equal the others. The print is marked with a Y and the exposure and developer data as before; the final correction when necessary being given, as described later, when making the Carbro positives.

Washing, Drying and Removal of Blemishes

The bromide prints, after fixing for at least 15 minutes (Kentmere bromide paper only 5 minutes), during which time they should be moved about to ensure complete fixation, should be washed thoroughly in running water, or many changes of water, until completely free from hypo. This is important, as any hypo left in the prints will combine with the potassium ferricyanide of the Carbro bath, and permanently reduce the bromide and prevent its satisfactory use for a second Carbro.

Although, after washing, the bromide may be used for the Carbro images without first drying them, it is better that this should be done, as when dry it is easy with a sharp knife

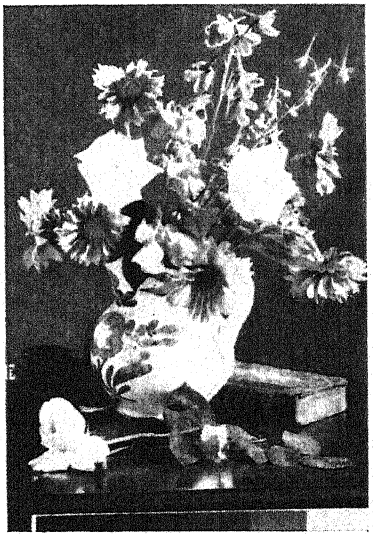
Time in No. 2 Carbro Bath—25 seconds

Time in No. 2 Carbro Bath—25 seconds

Time in Carbro Bath—15 seconds

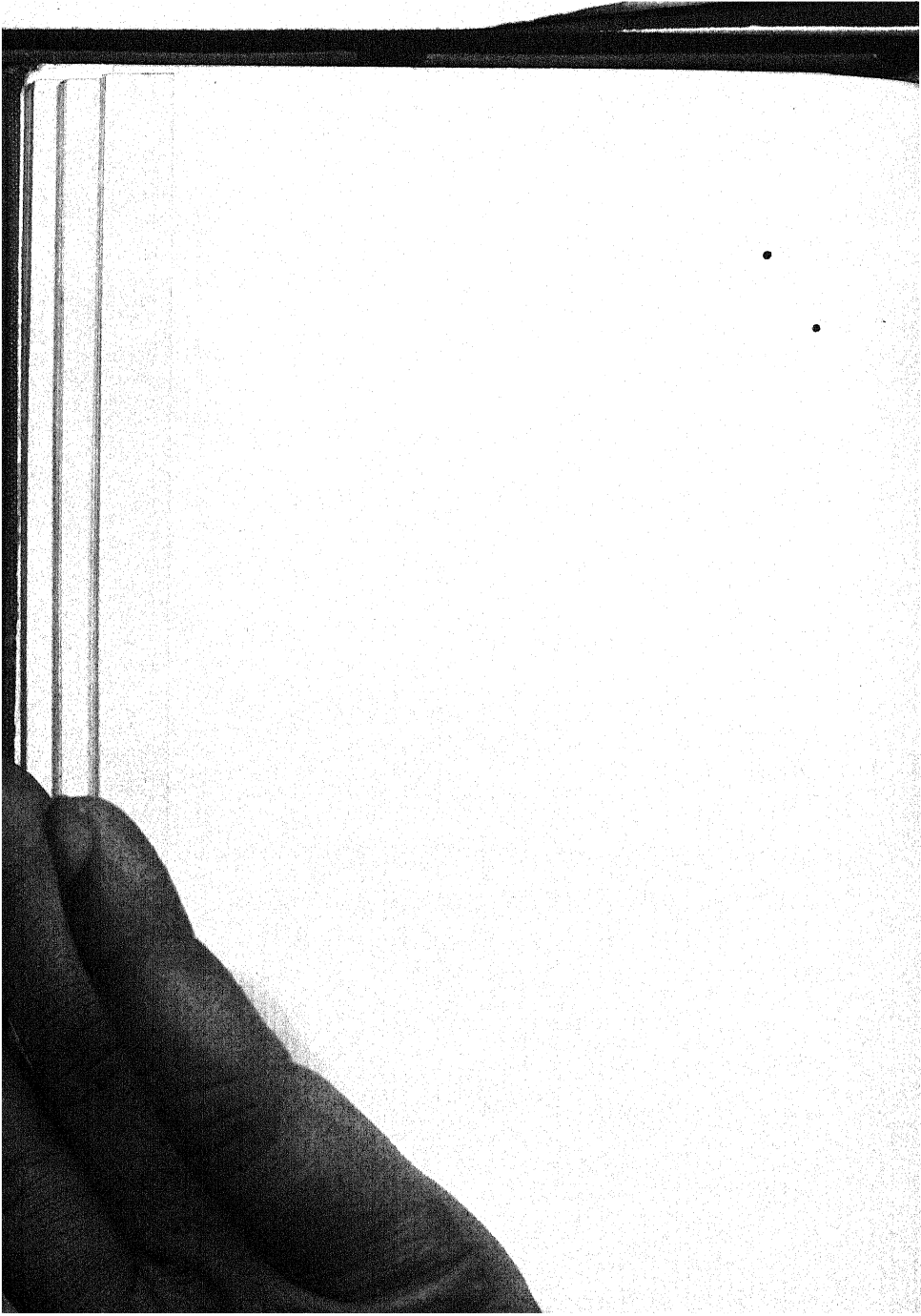
5

6



7

4. Colour Positives from 3. Note that time of immersion of yellow colour sheet in No. 2 Carbro Bath was decreased in order to make contrast of wedge equal to that of Blue and Red. 5. Blue and Red Positives combined (in Double Transfer). 6. Blue, Red, and Yellow Positives combined. Note appearance with opaque yellow image on top. 7. The three images transferred to the final support; the yellow image is now beneath the others, and the finished print is the result.



(preferably using the back edge ground to a sort of chisel edge) to pare or scrape off any blemishes or spots there may be.

White spots and marks are left alone, it is useless to spot them out as the pencil or other medium will not affect the Carbro tissue, but the resultant light marks on the finished print can be spotted out with red, blue or yellow dye or by

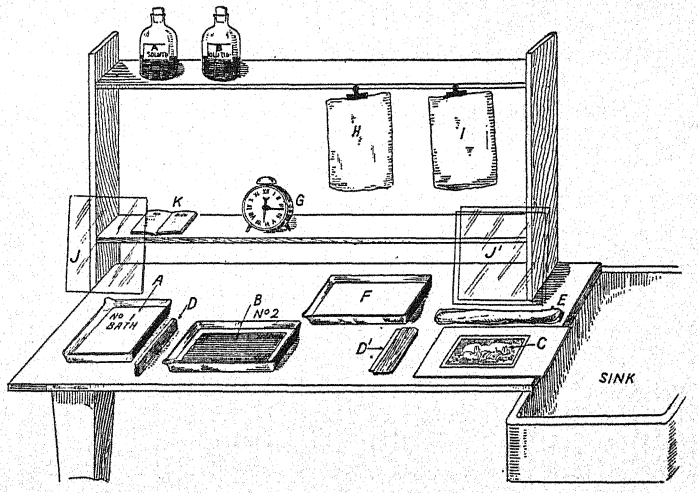


Fig. 3.—Work from left to right. A, dish with No. 1 bath in which the colour sheets shown hanging up have already been immersed. B, No. 2 bath, dish placed longways on bench, and with blue colour sheet immersed in solution. C, bromide print lying face upwards on sheet of glass; note white margin round image. D and D^1, squeegees in readiness. E, cloth for dabbing squeegee upon. F, dish containing the "red" and "yellow" bromide face downwards. G, clock with second hand. H, I, red and yellow colour sheets after immersion in No. 1, hanging from clips ready for immersion in No. 2 bath. (Note that these must not be hung where there is any danger of solution dropping from them on to the bromide prints.) J and J^1, sheets of glass ready for squeegeeing. K, notebook ruled out for data of procedure, times, &c., to be inserted.

a combination of these. But dark spots of colour are not so easily removed in the finished print, and it is better to remove the cause of them from the bromide prints.

Use of Acid Bath

Before the Carbros are made, the bromides must first be given 2 or 3 minutes immersion in a 2 per cent acetic acid bath:

Acetic Acid Bath

Glacial acetic acid	2 dr.	4 c.c.
Water	12 oz.	200 c.c.

This may be given before drying, but it is perhaps better to do so after, so that, by making it a rule always to do so, it does not get omitted.

Its purpose is to remove the effects of lime in hard water districts and any trace of developer sludge after redeveloping, and is quite essential, or all kinds of curious markings result.

The dry bromides should be soaked in cold water for at least five minutes before putting in the acid bath, or it will be difficult to wash out the acid, and the prints should be well swabbed over with cotton wool before being put to wash in running water for 10 minutes.

Laying out the Bench for Carbro Procedure

This time can be spent in preparing the sensitizing baths and in laying out the bench.

The accompanying sketch will show how this latter may be done (fig. 3).

Solutions and Materials Required

The stock sensitizing solutions (A and B) are compounded as under:

Stock Solution A

Potassium ferricyanide	2 oz.	1 gramme
Potassium bromide	2 ,,	1 ,,
Distilled water	20 ,,	10 c.c.

Stock Solution B

Potassium bichromate	360 grains	36 grammes
Chromic acid	100 ,,	8 ,,
Chrome alum	200 ,,	20 ,,
Distilled water	20 oz.	900 c.c.

Working Baths. *No. 1 Bath*

Stock solution A	1 part
Distilled water	4 parts

No. 2 Bath

Stock solution B	1 part
Water	4 parts

Note.—About 10 oz. (300 c.c.) of solution should be used for 10 × 8 prints of each No. 1 and No. 2 baths. No. 1 may be used repeatedly and will keep for about 2 weeks after use. No. 2 must be thrown away and fresh bath prepared for each set of colour sheets.

Note.—It is advisable to use distilled water for compounding the No. 1 bath, as in hot weather chemicals are added to the tap water supply which will often cause very intense veiling and even insolubility of the tissues. The comparatively short time this tissue is immersed in the No. 2 bath usually obviates the necessity of using distilled water for this, but should veiling become noticeable it is advisable to use distilled water in its preparation.

In compounding stock solution B, water warmer than about 100° F. (38° C.) should not be used, or an alteration in the composition of the bath takes place which may cause excessive tanning of the colour sheets.

Waxing Solution

About 5 grains of the waxing compound (a piece about the size of a pea), (obtainable from the Autotype Co., or it may be made by melting together ½ oz. spermaceti wax and ½ oz. white beeswax), should be shredded up into a bottle containing 5 oz. of good quality petrol or benzole mixture. A bottle with a sprinkler top serves admirably for waxing purposes.

Chrome Alum Solution

A stock solution of chrome alum of a strength of

Chrome alum	1½ oz.	40 grammes
Water	20 oz.	500 c.c.

will be needed for adding to the first dish of hot water used for developing the Carbro positives.

Use about 2 oz. to the quart of hot water (200 c.c. to 1000 c.c.).

Methylated Spirit Bath

1 part methylated spirit .. .. 2 parts water

Two waxing blocks should be made of wood, one measuring about $1\frac{1}{2} \times 1\frac{1}{2} \times 1$ in. ($4 \times 4 \times 2{\cdot}5$ cm.), the other $4 \times 1\frac{1}{2} \times 1$ in. ($10 \times 4 \times 2{\cdot}5$ cm.), which should have glued at the

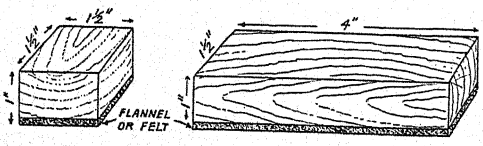


Fig. 4

bottom of each a piece of thick flannel or felt as shown in fig. 4. These are of great assistance in waxing the celluloid sheets, and a small piece of cloth about 2 in. square can be used on the smaller one for waxing purposes; the waxing solution will make it adhere to the flannel and it can be changed occasionally when worn or dirty. A larger piece of soft cloth, folded in half is put under the larger block, one side being used for the initial polishing. This is turned over and the other used for the final polishing off. The piece of cloth should be changed when it begins to get stiff with wax.

What is Required

The following articles and materials will be required and should be got ready before beginning operations:

The bromide prints, marked B, R, Y on the backs and placed face downwards in this order (Y at bottom) in a dish of cold water as shown in sketch.

3 sheets of celluloid at least 2 in. (5 cm.) longer each way than the prints.
3 colour sheets (blue, red and yellow) an inch (3 cm.) longer than the bromides.
1 piece of soluble temporary support paper same size as colour sheet.
1 piece of final paper support of same size as colour sheet.
4 sheets of glass, same size as celluloids.
2 flat squeegees at least as long as width of colour sheet.
3 porcelain or enamel dishes large enough for colour sheets (i.e. 2 for sensitizing solutions, 1 for bromide).
1 larger dish, some inches larger than the celluloids for developing Carbros.
Methylated spirit bath as above; this should be mixed some time before use to enable the rise of temperature caused by mixing spirit with water to subside.
1 roller squeegee.
Some sheets of paper (newspaper will answer).
6 paper or cloth clips.
Quantity of hot water.
Some cotton wool; clean soft rag; bottle of petrol and undiluted methylated spirit; thermometer; watch or clock with seconds hand; and a swab for dabbing squeegee upon.

This list looks somewhat formidable, but most of the articles are in common use in the dark room, and in point of fact the requirements of almost any photographic procedure are greater than the worker sometimes realizes, and Carbro is no exception to this rule.

It will be found of great assistance to keep a record book in which to enter various data, such as order of immersion, times in No. 2 bath, &c. Such particulars ensure a reasonable degree of accuracy in duplicating results, and provide the means for making corrections if it is found that the first pull from the bromides does not give a correctly balanced result.

The longer the time the colour sheet is left in the No. 2 bath, the flatter and weaker the result will be, while if it is desired to *increase* the contrast of the image, then the time of immersion must be *decreased*. This is due to the effect of the chromic acid upon the mixed constituents of the sensitizing baths.

In effect, the No. 2 bath is the control bath, so that should the first pull from the bromides give a result in which the blue image is obviously too contrasty (the middle and shadows tones too dark), then this can be remedied when making the second pull from the bromides by *increasing*—by say 5 seconds—the time the blue colour sheet is left in the No. 2 bath. Conversely, if on examining the bromides before beginning, it is seen that the wedge of the yellow bromide, for example, is too flat, then more contrast will be obtained by shortening the time by 5 or 10 seconds in the bath.

The ruling shown here indicates the idea and how it works; the details refer to the illustrations facing pp. 34 and 44.

Subject &c.	Order of immersion and times in No. 2	In No. 1 Bath	Off Bromide	Developed at	Remarks
Flower Study, 1st pull from bromides.	B, 20 sec. R, 25 sec. Y, 20 sec.	10·15 a.m.	10·30	10·45	Blue too strong Yellow lacking contrast
Above bromide redeveloped, 2nd pull.	B, 25 sec. R, 25 sec. Y, 15 sec.	3·5 p.m.	3·20	3·35	Balance corrected

The above shows the manner in which the record book (an ordinary exercise book) should be ruled, and the manner in which it is filled in.

It will not only be found useful for the purpose indicated, but will inculcate a systematic method of working, and a means of impressing upon the beginner's mind the sequence of the various operations.

The method of control shown is usually sufficient, and it is only when the worker begins to get more critical of his work that the third method of control, that of altering the order of immersion, need be considered, as the alteration obtained is very slight. It will, however, be found that should, for example, the red image be generally *slightly* too strong when making the second pull, if it is done first and the blue

second, then it will be slightly weaker and the result improved (the images gain slightly in strength the longer the time before development).

Procedure

Assume everything to be ready and the bench laid out as shown in sketch, the appropriate quantities of No. 1 and 2 baths poured into the dishes (the quantity of No. 2 especially should *not* be stinted or the tissues may be insufficiently tanned), and the clock placed with seconds hand easily visible. The time and position of seconds hand should be noted and the blue colour sheet slipped into No. 1 bath face upwards; remove with the finger tips any air-bells adhering to its surface, and then turn over face downwards and keep moving gently about. After 30 seconds, the red colour sheet is immersed in the same manner and 30 seconds later the yellow. (Beginners may find it easier to give 1 minute interval between each immersion.)

All should be kept slightly in movement, so that even and full saturation by the solution is secured.

When 2 minutes have gone (note that in hot weather this may be reduced to 1½ minutes or increased in very cold to 2½ minutes, the point for removal being reached when the paper has fully expanded, and just prior to its beginning to curl backwards), the blue colour sheet is withdrawn, laid face up upon the sheet of glass (J, fig 3); the surplus solution is squeegeed back into the dish with one stroke of the flat squeegee, and the sheet is hung up by the paper clip as shown at (H). 30 seconds (or 1 minute as the case may be) later, the red sheet is treated similarly, followed by the yellow.

The " blue " *bromide print* is next drawn steadily out of the dish of water, so as to leave a thin film of water on its surface, and laid face up upon the glass sheet, as shown at C in fig. 3.

The blue colour sheet is then taken down as shown at C in fig. 3, and immersed in the No. 2 solution. Note that the

front edge of the colour sheet is drawn taut between the fingers and thumbs as it is passed slowly and smoothly under the surface of the No. 2 solution (fig. 5). When the edge reaches the other side of the dish, the latter is tilted towards you so that the liquid flows evenly, without air-bells forming, over the surface of the sheet. The dish is rocked so that the solution is kept in motion. The time by seconds hand being noted *immediately* the tissue is immersed.

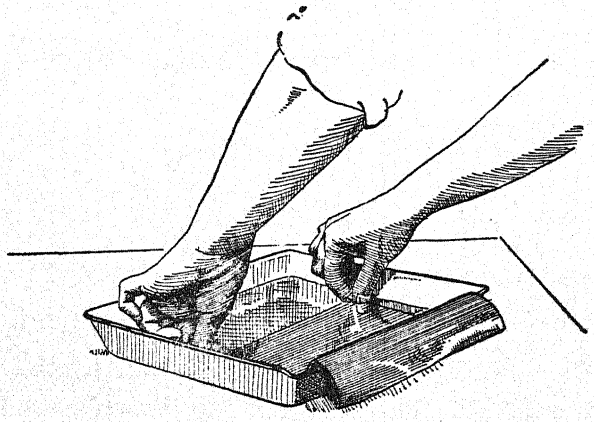


Fig. 5.—Immersion of Colour Sheet in No. 2 Bath

At the expiration of the time decided upon, say 25 seconds, the colour sheet is seized at the left near corner with the finger and thumb of the right hand, the thumb being beneath the sheet, and drawn steadily but fairly quickly out of the dish; as the other end leaves the dish it is taken hold of with the left finger and thumb so that the coated side of the sheet is below, and the thumbs of both hands are on top. Lay the left edge down on to the left edge of the bromide print, overlapping this slightly, and press the overlap down on to the glass firmly with the left finger and thumb, and lower the sheet quickly but gently on to the bromide print (fig. 6). At once take the flat squeegee in the right hand and, starting

from close against the left finger and thumb, take a firm swift stroke away to the right (fig. 7). Repeat once, and then turn the glass round, press down the edge again with left hand, and squeegee again in the same manner. Take a stroke each way at right angles and then stand the glass on edge, with the "sandwich" on it against the wall, so that it will not get splashed, and will be neither in strong sunlight nor in a draught.

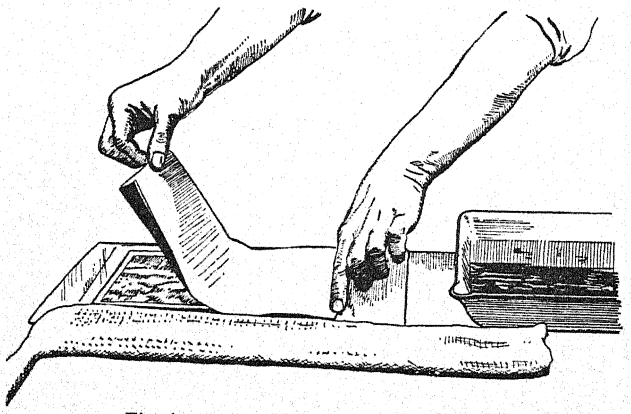


Fig. 6.—Applying Colour Sheet to Bromide

Proceed in an exactly similar manner with the red and yellow colour sheets and leave for 15 minutes. (In hot, dry weather the time should be shortened to 10 minutes or even less, or difficulty may be experienced in stripping colour sheet and bromide apart.) The No. 2 solution is thrown away, the dish rinsed and filled with the spirit bath in readiness.

In order to make these directions intelligible to the beginner, they must perforce be somewhat lengthy, and maybe read as if the operation is a long and somewhat difficult one. Actually, this is not the case, for all three colour sheets can easily be applied to the bromides within 3 or 4 minutes at the outside.

It is advisable for practice to go through the procedure two

or three times with old bromide prints and sheets of paper, using water instead of the solutions, until the order of the operations has been impressed upon the mind and the knack of squeegeeing, &c., acquired. The whole thing thus becomes

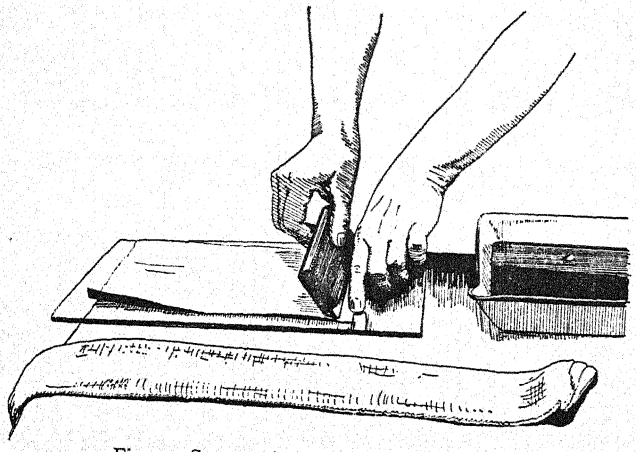


Fig. 7.—Squeegeeing Colour Sheet to Bromide

extremely quick and simple and waste of material is avoided. It is desirable that the method outlined (which is the result of years of experience) should be adhered to as closely as possible, and that one's methods should be standardized—if this be done, all kinds of snags and pitfalls are avoided.

Waxing the Celluloids

During the 15 minutes interval the celluloids should be waxed and polished off in readiness. When the celluloids are new and very shiny it is advisable to wash them well over with a slightly abrasive soap, like "Monkey Brand" or "Vim", which give a slight "tooth" to the surface without scratching it, and so permit better adhesion of the colour sheets. When new the wax coating should be allowed to dry

for 2 or 3 minutes before polishing, or too much may be removed.

One corner of each sheet should be cut off, and if the sheet is laid on the bench for waxing with this corner *always* at the top right, then it is easy to remember which is the waxed side and to lay the celluloid down in the same way when squeegeeing.

To wax the celluloid, a fair amount of the waxing solution (the amount of wax indicated earlier will just dissolve in the petrol and leave a practically clear solution) is sprinkled on the cloth of the small waxing pad *and* on the surface of the celluloid, and rubbed thoroughly all over so that every portion is covered. The larger polishing pad and cloth are then taken and rubbed vigorously over it; when surface dry, the folded cloth is turned over and the celluloid polished off with this until, on drawing a dry finger across, no trace of any mark can be seen, a matter of say half a minute's polishing. Should too much wax be left on, frilling of the Carbro image may result. It is almost impossible to polish off the wax entirely, so avoid too little polishing.

The celluloids when waxed may be clipped up on other clips in readiness. Wooden clothes clips may be nailed through one end on to a batten and form a very convenient way of drying the developed Carbro images, &c.

Stripping Colour Sheets from Bromides

The blue " sandwich " is removed from the glass and the colour sheet pulled gently off the bromide and immersed face upwards in the methylated spirit bath for about 1 minute.

The colour sheet should need a slight " pull " to separate it from the print; if it falls apart too easily it indicates either that it was left too long in the No. 1 bath, or that it was not squeegeed firmly enough to remove excess moisture, and " frilling " may possibly occur when developing it on the celluloid. The celluloid sheet, waxed side uppermost, should be laid upon the glass sheet from which the sandwich was

removed, and the flat squeegee and folded swab placed in readiness. At the expiration of the minute, the colour sheet should be removed from the spirit bath and laid face down upon the celluloid and squeegeed firmly. This operation should be carried out in the same manner as the removal from No. 2 bath and squeegeeing to the bromide.

The celluloid and colour sheet is then laid aside between the sheets of newspaper, the red and yellow colour sheets are treated similarly and placed on the other with paper between and paper over them and left for 15 minutes, during which time the glasses should be wiped clean and put away, the bromides put to wash, the No. 1 bath poured into an empty bottle (straining through muslin to remove any particles) and put aside for future use, empty dishes put away and the bench wiped down.

The bromide prints should be dropped into a dish of cold water to be washed and redeveloped later.

Developing the Carbro Images

The large dish should then be filled with water at about 100°–105° F. (38°–40° C.), to which the chrome alum stock solution has been added in the proportion of 2 oz. to each quart of hot water (200 c.c. per litre). If running hot water is not available, more should be got ready for replenishing the dish as required.

At the expiration of the 15 minutes the pile of celluloids is turned over and that bearing the blue image is immersed in the hot water.

Method of Immersing Celluloid in the Hot Water

Here again the method employed is very important; the celluloid must *not* be just slipped into the hot water, or almost certainly large areas of the image will float off after stripping the paper backing. Instead, the celluloid must be taken in both hands and held horizontally with the colour sheet beneath and the ends bent upwards *slightly*, so that the celluloid is

curved as shown in fig. 8. It is then *pushed* firmly down on to and beneath the surface of the hot water and completely immersed. After it has been under the water for 15 or 20 seconds it is turned over, and after a few seconds the corner of the paper backing is picked up with the finger and thumb, and the paper peeled carefully off and thrown away (fig. 9). The corner of the celluloid is then taken and—still under the surface of the water—it is shaken laterally and tapped gently

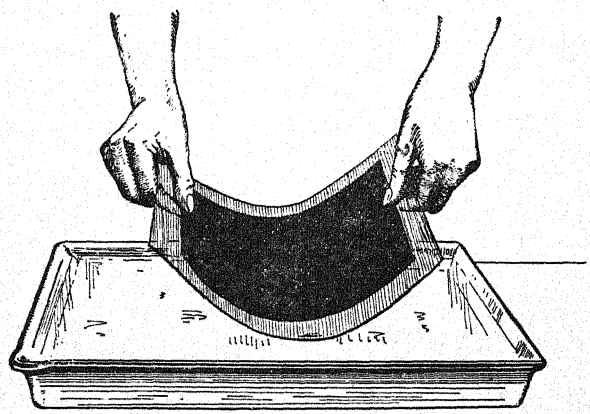


Fig. 8.—Immersing Celluloid in Hot Water

against the side of the dish to dislodge as quickly as possible the soluble and unwanted pigmented gelatin. It must not be left stationary, or the chrome alum will harden particles of the pigment, which will be difficult to remove. The chrome alum is used to prevent undue softening and swelling of the developing image, the primary cause of frilling, but if excess of alum is used or the celluloid is not moved, the unwanted pigment may be tanned, with unfortunate results.

Lift the celluloid repeatedly from the water so that it may drain rapidly and when most of the unwanted pigment has washed away, throw away the hot water and rinse and replenish the dish with plain hot water (no chrome alum should

be added to this). Repeat the shaking and draining until no colour at all can be detected in the water draining from it. Pour some cold water gently over the surface of the image and hang to dry. Drying will be facilitated if the *back* of the celluloid is wiped free of drops of water with an absorbent cloth. The same procedure is followed with the other two colour sheets.

If the procedure outlined is followed carefully, and the

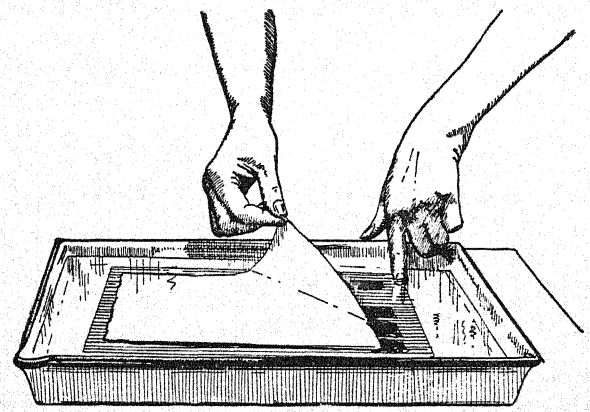


Fig. 9.—Stripping Paper Backing off Celluloid

delicate nature of the wet image is borne in mind, no trouble will be experienced at ordinary room temperature, and the whole operation from beginning to end may be completed within three-quarters of an hour. In the writer's own practice, he usually works two sets at a time, one set following immediately on the other through the various operations, so avoiding the two 15-minute waits, and both sets are then completed within an hour.

Transferring the Colour Images to the Paper Support

In the finished picture it is essential that, owing to its opacity, the yellow image shall be at the bottom, and it would seem best to transfer the yellow image on to the paper support

first. This can be done, and the method is known as the single transfer process, but it has the disadvantage of being more difficult to register one image with the other (the red and yellow being difficult to see one against the other, especially in artificial light); also one is restricted to a shiny and somewhat inartistic surface. Further, the image will be reversed from right to left, so that if for any reason this method is adopted, care must be taken to reverse the negatives when making the enlarged bromides. The "double transfer" method only necessitates one further operation and eliminates these difficulties; by adopting it one is able to transfer the combined images to various kinds of beautiful papers, rough, matt, canvas grain and the like, as well as on to prepared glass, wood, or textile fabrics if desired. These latter have to be coated with a substratum of hardened gelatin before the transfer can be accomplished.

Double Transfer Method

While the images are drying on the celluloid, the bench should be cleared and the hot-water dish rinsed free of colour and filled with cold water. Into this, the soluble temporary (paper) support (the same size as the colour sheets) should be placed to soak and fully expand. Five minutes' immersion is sufficient and care must again be taken to see that no air-bells adhere to the gelatin surface, which should be face downwards.

The celluloid bearing the dry blue image is then slid beneath the paper and the two are withdrawn from the water, the paper being tapped with the tips of the fingers, as it leaves the water, to dispel any air-bells. It is allowed to drain for a moment or two and then laid on the sheet of glass, paper support on top, and squeegeed carefully with the flat squeegee. A sheet of dry blotting paper is laid on and the roller squeegee passed over to remove as much moisture as possible. The back of the celluloid is dried and it is hung in a current of warm dry air to dry, a matter of about half an hour.

When *quite* dry, the paper bearing the blue image will peel off of its own accord; it must on no account be *pulled* off or the high lights will be left on the celluloid and the picture spoiled. The removal of the image may be assisted by gently bending the celluloid backwards and forwards, but no more than this is permissible.

Removal of the Wax

The blue image will bring away with it some of the wax from the celluloid, and it is absolutely essential that all of this should be removed.

This is done by sprinkling a good quality petrol on to a piece of cotton wool and going over the surface two or three times, turning over the cotton wool and shaking on more petrol, and finally wiping over and polishing off with a piece of soft cloth. This latter, too, is quite essential, as it is impossible to completely remove the wax with cotton wool alone, and failure to do so will prevent the next image adhering properly and, on stripping, portions will remain on the second celluloid.

Further, a very highly rectified petrol or benzine is not suitable, as it evaporates before it is possible for the wool or cloth to absorb and remove the wax.

It may seem incredible that such apparently unimportant details as the substitution of cotton wool for cloth can either make or mar the result, yet it is so. This point was one which caused endless trouble to many workers until this precise cause of trouble was discovered, and serves to emphasize the advice given in the preface, that it is the small things which spell success in colour photography.

The willingness to pay attention to these small details, which seems so often to be the prerogative of the beginner and amateur, is often the reason why he succeeds when the experienced photographer, who pooh-poohs the necessity for doing certain things in a certain way (not, as will be realized, necessarily more difficult or tiresome, but quite definitely

" certain " ways in more senses than one) fails again and again and finally dismisses the *process* because *it* is so uncertain.

Registration of the Blue with the Red Image

After the complete removal of the wax the most fascinating

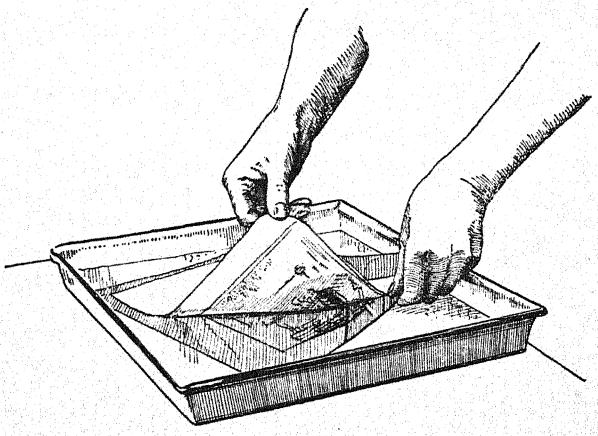


Fig. 10.—Sliding Celluloid bearing Red Image beneath Soluble Support bearing Blue Image

part of the process arrives—the registration of the red with the blue image.

The paper bearing the blue image is soaked, face downwards, for 2 or 3 minutes in the large dish of water for full expansion to take place, and the celluloid bearing the red image is slipped beneath it (fig. 10). After about 15 seconds (time enough for the red image to become saturated) the two are withdrawn as described before, and while draining, turned so that the two images can be seen through the celluloid. The paper is moved about until fairly accurate register is obtained. Then, carefully laying the celluloid down on the glass sheet with the paper uppermost, *gently* squeegee once with the

flat squeegee. Lift up and see that no serious movement has taken place; if it has, gently move the paper to bring it into register again, and then lay it down upon a sheet of blotting paper (paper underneath) on a flat surface, and with a watchmaker's magnifying-glass (see fig. 11), examine it carefully,

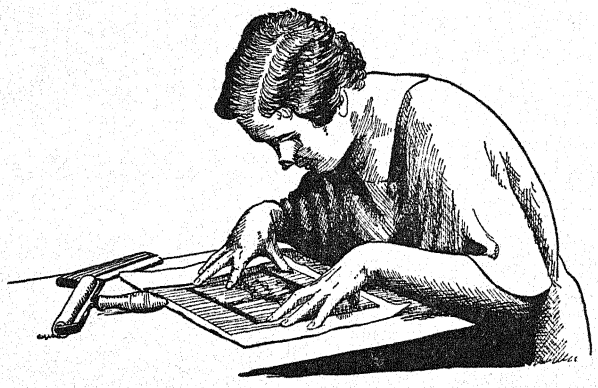


Fig. 11.—Registration of the Two Images

and where necessary push on the celluloid gently with the finger-tips in the direction the *overlapping red image is wanted to go*. With a fair amount of gentle pressure it is possible to get perfect register, provided no camera or other movement has taken place when the photograph was taken.

How to overcome Discrepancies in the Size of Images, and other Difficulties

Sometimes it is found that the blue image is slightly larger than the others. This may be due to the camera lens not being fully colour corrected. Usually the difficulty can be got over by placing a sheet of thin card or one of the celluloids under the bromide paper when making the " blue " enlargement, thus bringing it slightly nearer and making the reduction in the size of the image necessary to make it register with the others. The card or celluloid is removed when making

the red and yellow bromides. Failing this, it is usually possible to get more accurate registration by bending the celluloid so that the paper is on the outside of the curve and then with paper clips and string keeping it so while it is drying.

Should the subject be a contrasty one, considerable relief will be seen in the wet and swollen image. It is then advisable after registration to press firmly with a pad of soft dry cloth on to the thin high-light portions, so as to make them adhere to one another and prevent the paper from stretching across the heavy swollen portions, thus causing bad contact. If this is not done, the high-light may not adhere and the red portions may remain on the celluloid.

Sometimes when the first squeegee stroke has been taken and the two images are out of register it will be found difficult to move the paper. This is due to insufficient soaking of the red image, and force should not be used, but the celluloid returned to the dish of cold water, soaked for a few moments and then the paper peeled *very* carefully off, and the operation of registering repeated as before.

The image should be watched carefully as the paper is lifted, and if by mischance the squeegeeing has been so firmly done as to cause the red image to pull off the celluloid, do not persist, but replace the paper and squeegee again to make the best of a bad job by pushing into register as well as possible in the manner described above; but in most cases if this should occur the picture is spoiled.

In actual practice, however, such troubles seldom occur, if the directions given are followed carefully; but unless such details *are* given, prints which can quite easily be saved may be thrown away.

When register has been achieved, the blotting paper is laid on and roller squeegeed and the celluloid placed to dry as before. When it is dry, the wax is removed and the operation of registration is repeated with the yellow.

When dry and the paper has peeled off, the image

will present the appearance seen on the illustration facing p. 44.

Final Transfer

In the meantime the final support paper chosen, with a pencil mark on the back to prevent the temporary support being applied to the wrong side, is put to soak for about 10 minutes in cold water. Should the pencil mark be omitted, the coated side can be determined by rubbing the paper at the corner with considerable pressure between the finger and thumb, when the *back* of the paper will begin to rub up in little rolls of paper.

It is essential that the image goes on to the *coated* side of the final support or it will wash off when transferring. The wax on the yellow image is thoroughly removed as before, and then it is slipped face towards the coated side of the final support in the cold water (air-bells being avoided as before) and soaked for *not more* than 30 seconds, i.e. until just flaccid. The two papers are then withdrawn, tapped again with the finger tips to avoid inclusion of air-bells, laid upon the glass, temporary support uppermost, and squeegeed firmly in all directions, first with the flat squeegee and then with roller squeegee and blotting paper.

It is placed between two sheets of the latter in between two sheets of glass; and a fairly heavy weight, such as a thick book, or bottle of solution or water, &c., is placed on top for about 10 minutes.

A pleasing method can be adopted to obviate the necessity for after mounting. In this case, the final support is considerably larger than the temporary support, and *after* cleaning off the wax, and *before* soaking, the picture is trimmed square to the size required, and then after soaking as described above, is carefully centred in the required position on the final support. This should be just above dead centre to give the most pleasing effect, as in ordinary mounting, and the final support then serves as a mount.

Final Transferring of the Combined Images

The large dish should be filled with water at about 115° F. (46° C.), and after the 10 minutes have expired, the final transfer paper and temporary support, the latter beneath, should be floated on top of the water and left so for about a minute. When the corners begin to curl upwards it should be pushed gently beneath the water and left so for a moment or

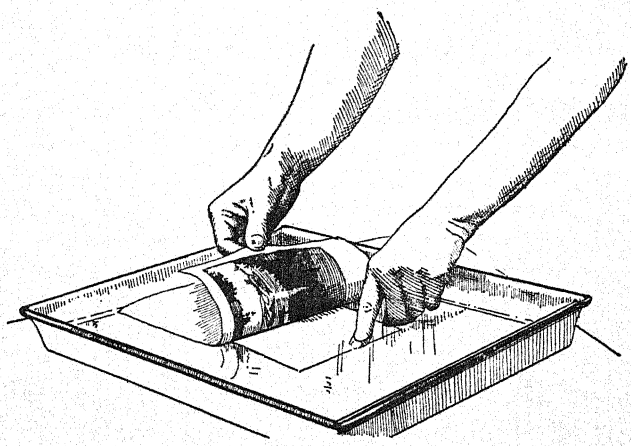


Fig. 12.—Removing Picture on Final Transfer from Temporary (Paper) Support

two, and gently tapped until the air bubbles which come out of the paper disappear.

By this time the soluble substratum of gelatin on the temporary support will have melted, and by bending back carefully the final support paper, the former will be seen to start leaving the latter. Very carefully, especially in the case of the already trimmed print, the corner of the unwanted paper is pressed with a finger of the left hand to the bottom of the dish, and the final support bearing the finished picture slowly peeled off (fig. 12).

The temporary paper support is thrown away, and the

surplus soluble gelatin on the surface of the picture washed away by gently laving with the finger tips, or pouring the warm water on with a small measure. The print is then immersed in a dish of cold water for a couple of minutes to set any soluble gelatin there may be and so avoid shiny streaks on the dry picture. Then the finished result is hung to dry. The more slowly the drying takes place, the more matt the surface will be when dry.

When it is quite dry any spotting or finishing is done by means of red, blue and yellow dyes (pigment or water colour is not so suitable, as it shows up), either used separately or mixed to match the colours of the picture, and finally some of the waxing solution is shaken on it and polished off to provide both a protective substratum of wax and give a lustrous sheen to the picture.

The Autotype Company supply two kinds of red tissue, one of which it is possible to bleach out of the finished picture, and another in which this is not possible. The latter tissue is quite permanent in character and will not fade; the former may fade slightly if exposed for a prolonged time to strong sunlight.

The amateur may prefer to use this red tissue since it gives him control denied by the other, and if the finished picture should be too red, it should be soaked for 5 minutes in cold water and then immersed in a very weak bath of the following bleaching bath:

Bleaching Stock Solution

Potassium permanganate	5 grains	·5 grammes
Sulphuric acid	10 drops	·5 c.c.
Water	20 oz.	1000 c.c.

The working bath should be very dilute, sufficient of the stock solution being added to a dish of cold water to turn it a moderate pink. If the bath is too strong the action is too rapid. It must be watched carefully, and when sufficiently bleached, rinsed in water and placed in a clearing bath of

Potassium metabisulphite	50 grains	6 grammes
Water	20 oz.	1000 c.c.

until clear of colour and then washed for 10 minutes in cold water.

No satisfactory bleacher has been found for the blue or yellow images.

Failures and How to Avoid Them

Frilling.—The colour positive, when being developed on the celluloid, wrinkles up and pulls off the celluloid. This occurs sometimes in warm, humid weather. The time of immersion in No. 1 bath should be shortened to 1½ minutes. Remember to add the chrome alum solution to the hot developing water; failure to do so will cause this trouble. If large areas break away as soon as development starts, the celluloid may have been bent *too* much when immersing in the hot water; hold the ends of the colour sheet with the finger tips as you push beneath the water.

Difficulty in stripping backing paper when developing.—Too much chrome alum may have been added to developing water. The colour sheet may have got too dry before development. The water may not have been hot enough—it must not be less than 100° F. (38° C.); or the cause may be the water supply, as indicated in the paragraph on " general veiling ".

Patches of small light and dark circles.—These only occur in very warm, humid conditions, and are caused by the pressure from the air-bells which form under the backing paper before stripping, owing to the very tender condition the tissue is in. If possible, wait for better weather conditions. If this is impossible, shorten time in No. 1 bath as much as possible, avoid excessive drying on celluloid, and strip off paper backing as soon as possible after immersion.

Irregular dark and light spots.—Irregular *light* spots are caused by air-bells adhering to the surface in No. 1 bath; similar *dark* spots by air-bells in No. 2 bath. The remedy in both cases is obvious.

If these marks are larger than air-bells, they are probably caused by froth on the surface of the No. 1 bath, due possibly

to staleness. Use fresh No. 1 bath and strain through fine muslin to remove froth bubbles when pouring into dish. Don't forget to lay tissue face *up* on glass when squeegeeing prior to hanging up.

General veiling over the whole picture.—When this includes the part of the tissue which overlaps the bromide print, it is probably due to the addition of chemicals to the water supply by the authorities. This is done in hot weather to keep it sterile and may cause intense veiling and even general insolubility of the tissue.

If this is suspected, use distilled water for compounding the working baths as well as the stock solutions. The tissues once sensitized are slightly light-sensitive even when wet, and if the workroom is very sunny, yellow curtains over the windows will help to avoid trouble. Always keep the sandwich of colour sheet and bromide out of direct sunlight.

Uneven patches of colour in the finished result.—These are probably due to faults in manipulation, and will disappear when more skill has been acquired. It is for this reason that it is important to note such details as the manner in which the bromide prints should be removed from the water, before laying on the glass to receive the colour sheet. The bromide should be withdrawn steadily from the water, in order to retain an even film of water on its surface; and, for the same reason, the colour sheet should be withdrawn steadily, and laid without draining upon the bromide. If the bromide is drawn out carelessly, it will have patches without water on its surface, and others with water. This alters the dilution of the sensitizing bath on the surface of the tissue, and tends to produce patchy results. For these reasons, the method of working should be systematized, so that each process is carried out in the same manner every time a print is made.

THE DUXOCHROME PROCESS

This process presents several novel features and is perhaps the quickest method of producing colour prints that has yet been evolved. It depends, as does Trichrome Carbro, upon first making a set of three-colour separation negatives by any of the methods described in Chapter III, but differs from Carbro in that the colour used for producing the positives is incorporated with a silver emulsion sensitive to light coated upon thin celluloid supports. The positives are the result of exposure, development and the washing away of the untanned and unwanted portion of the colour emulsion, in hot water. The result, a gelatin colour image in relief, is very similar to that produced by Carbro.

This direct method of making the colour positives, obviates some of the difficulties present in Carbro, for example the washing away of the high-light tones, and the frilling occasionally experienced during the hot-water development, the image being definitely tougher than the Carbro image. Against these advantages must be set the fact that there is no intermediate guide, such as the bromide prints one has in Carbro, which affords such valuable help in determining the correct balance of strength and contrast of the subsequent colour images.

The leaflet issued by the makers of Duxochrome covers the production of the prints very adequately, but in practice the author, as a result of experience in other processes, has made certain modifications which seem advantageous, and the following notes will serve to amplify the official instructions.

Firstly the negatives should be well balanced, as it does not appear to be so easy to correct ill-balanced negatives as is sometimes possible with Carbro.

The speed of the Duxochrome emulsions is high, about the same as the average bromide paper, and it must therefore be handled by an orange safe-light and on no account exposed to white light before fixation is complete. The different

colours differ in speed, the red being somewhat slower than the blue and yellow.

The celluloids are packed between black wrappers, and small pieces are provided for preliminary test exposures.

The various solutions should be prepared in readiness, but only the Duxochrome developer and an acid fixing bath are required for the first part of the operation carried out by the orange safe-light.

After fixation, the other operations can be carried out in daylight and the other solutions, &c., got in readiness then.

As mentioned above, the speed of the three emulsions is not the same, and although no definite information can be given, the following figures may be a rough guide and of some assistance in commencing to work this process.

The set of negatives from which these figures are taken was of average balance, such as one would reasonably expect to work from, as the bromide exposures given indicate.

Exposures given to bromide prints for Carbro:

Blue, 10 sec. Red, 8 sec. Yellow, 9 sec.

Exposures for Duxochrome positives:

Blue, 10 sec. Red, 30 sec. Yellow, 20 sec.

It must be borne in mind that this information *can* only be the roughest indication, as obviously bromide papers alone vary very much in speed and it is probable that similar variations occur in different batches of Duxochrome material, but they may serve as a starting point, and *always* one must make test exposures before making the colour positives proper.

The amount of developer necessary for three half-plate colour positives is

1 oz. 30 c.c. of Duxochrome A stock solution.
1 oz. 30 c.c. of Duxochrome B stock solution.
10 oz. 300 c.c. of *distilled* water.

This may be put into one dish and the three positives developed together. As, however, it is not at all easy to handle

the three thin celluloid supports so as to change them over repeatedly during development, the writer prefers to use three separate dishes, the same amount of developer being amply sufficient, divided among the three dishes.

It is important that the temperature remains constant, and while about 65° F. (18° C.) is ideal, it is wise to have it at room temperature so that it does not fluctuate, increasing the time if the room is cooler, decreasing if warmer than this. The normal time at 65° F. (18° C.) is 4–5 minutes.

To make the test exposures, one of the strips is laid with the shiney base of the celluloid *towards* the light, if enlarging, or *against* the negative if printing by contact, as it is absolutely imperative that the exposure be *made through the base of the support*.

The colour printed from each negative is the same as in Carbro and other subtractive process, i.e. complementary to the filter through which the negative was made, so that a piece of blue-coated celluloid is printed from the red filter negative. It is advisable to make step exposures (as in Carbro) when making the test, exposing all three, the red from the green filter and the yellow from the blue filter negative, and developing them for 5 minutes at 65° F. They are then put, without rinsing, into the acid fixing bath, and when the opacity has disappeared and the colours look translucent, the white light may be turned on.

Incidentally a faint image can be seen on the yellow and red celluloid, but the blue is invisible during development.

After fixation they are developed in hot water (120° F., 50° C.), and that part of the emulsion which has not been tanned by the special Duxochrome developer (none other may be used) will wash away in precisely the same way as in the Carbro process.

Although it is permissible to develop the test pieces in one dish of hot water, using fresh water until no more colour runs from them, the colour positives proper must each be developed separately. As soon as development is complete,

place in a dish of Farmer's Reducer (for strength see official instruction) until the grey silver image disappears and the image on the celluloid appears translucent.

Rinse in cold water to remove yellow of bleacher and then lay in rough register over one another in a white porcelain dish, to see which of the exposures give correct balance.

If widely out in the estimate, make fresh tests, but usually one of the step exposures given to each will be sufficiently near to enable one to judge what exposure to give to the full-sized pieces. When these are made, it is advisable to use a printing frame or mask giving a $\frac{1}{4}$-inch plain edge, so that they may be the more easily handled.

The developer must only be used once and that used for the test pieces should be thrown away and fresh measured out for the positive proper. When these have been developed and fixed, it will be found convenient to use a small " bull-dog " paper clip to hold each in when developing in the hot water, as it is not easy to pick the thin sheets of celluloid off the bottom of the dish.

Wash in several changes of hot water, until no more colour can be seen to run from them, rinse in cold, and bleach out the silver image in Farmer's Reducer.

Examine in register as before, and if balance is correct proceed as given in the instruction leaflet. If any one is too strong, it may be slightly reduced by developing further in hotter water.

If this proves insufficient, and the positive is *not* so strong as to make it wiser to make a fresh one (which can of course be easily and quickly done), further reduction may be achieved by means of a piece of soluble temporary support used in the Carbro process. This is coated with a soft gelatin and if soaked and squeegeed into contact with the image (avoiding air-bells) and left for 5 or 10 minutes, dye from the Duxochrome image will be imbibed by the gelatin on the paper and a considerable reduction effected.

This operation, however, *must* be carried out *before* the

hardening of the image in the Duxochrome fixation bath, which renders this method unworkable.

If by chance it has been so hardened, recourse may be had to chemical reduction, but this is a somewhat risky procedure, as the action, if care is not taken, is somewhat drastic. A *very* weak solution of potassium permanganate (only just tinged pink), to which has been added a drop or two of sulphuric acid, is poured into a dish and the wetted Duxochrome positive immersed in it and rocked for a few seconds. It must be taken out repeatedly and watched carefully or it may easily be carried too far. The blue if bleached too much will turn slightly pink in the lighter tones. As soon as sufficient reduction has taken place, rinse in cold water and immerse for a minute or two in a dilute solution (2%) of potassium metabisulphite, to remove stain, wash for 5 minutes, and hang to dry.

When the images are correctly balanced the rest of the procedure indicated in the instructions is carried out. The assemblage on to the paper support must be carried out strictly in accordance with the times given for soaking the paper, or it will be impossible to get accurate registration.

Personally, the author prefers to use the Soluble Temporary Support paper of the Carbro process, as provided this is sufficiently soaked to secure full expansion in the first instance, the times of soaking for subsequent registration are not critical. It can be used as a final support in the same manner as the Duxochrome paper, but it is somewhat flimsy for this purpose and the author prefers to use it as a temporary support in precisely the same manner as described in the chapter on the Carbro process.

The photograph can then be transferred to a variety of supports, *but* it is essential, if double transfer is done, that the Duxochrome images be hardened in the Duxochrome fixation solution for 5 minutes, or " bleeding " will take place (i.e. the soluble temporary support will imbibe dye from the assembled images and spoil the result).

Also this method reverses the final image, and if this matters, then the negatives in the enlarger must be reversed. Contact printing, unless film negatives are used, *must* result in a reversed result, as it is impossible to get any result at all if the Duxochrome tissues are reversed when printing, so if this is objected to the single transfer must be carried out.

CHAPTER IV

Colour Prints from Colour Transparencies

Both film and glass colour transparencies can be reproduced as paper prints by one or other of the printing processes described elsewhere, but some loss in the reproduction is, unfortunately, inevitable.

No paper print, however accurately it may reproduce the colours of the transparency, can hope to rival its brilliance and richness of colour, if only because one is viewed by reflected and the other by transmitted light. Nor is this the only factor affecting the result, as a moment's reflection will show. In order to reproduce the transparency, three colour extraction (or separation) negatives are made of it, just as though it were the original subject. If one compares in one's mind's eye, for example, a red-filter negative made from the transparency with one made of the original subject, one can realize that the former can scarcely record the full value of the red of the original, since in the transparency itself any red area there may be *looks* red because the blue and green dots of the mosaic in that area are obscured by the blackened silver of the emulsion covering them. So, in theory at any rate, there will be but approximately one-third of the light action

recorded that one would have in a negative made direct from the original subject.

This, of course, applies equally to the blue and green filter negatives, and to admixtures as well as the pure colours. Although, fortunately, owing to lateral spread of the light transmitted by the colour dots the loss is not quite so serious as this consideration would lead one to suppose, it does exist, and accounts in part for the lack of full colour saturation in the paper print when compared with the transparency. If allowance then is made for this, the results obtainable will be found quite satisfactory.

Prints made from transparencies with an irregular colour mosaic are apt to show more diffusion than those made from those of regular pattern (Finlay and Dufaycolor), owing, of course to the clumping together of dots of one colour which occurs in the former. This diffusion, however, can produce very pleasing prints if the subject is one of broad effects and the print is transferred on to one of the rougher final supports (202 &c.), especially if kept delicate in tone and transferred direct on to a large support as described on p. 64, when it will rival a water-colour in appearance.

Making the Colour Extraction Negatives

The transparency is treated precisely as if it were an original object, except of course that it must be illuminated by light passing through it and not upon it.

Ordinary tricolour filters may be used, but the writer prefers filters having narrow bands of transmission, such for instance as:

	Daylight Factor	½-watt Factor
Kodak No. 50 for the Blue	30	40
„ No. 61 „ Green	30	12
„ No. 29 „ Red	15	4

The factors given above are approximately correct for the Ilford Hypersensitive Pan Plates, and factors for other plates must be found by experiment.

In making the negatives it is important (1) that the transparency be perfectly evenly illuminated, and (2) that no light other than that passing through it should reach the negative plate.

There are many ways in which the extractions may be made if these facts are borne in mind. The transparency may be placed in a window, with the rest of the window blocked up and a white card placed behind it at an angle of 45° to reflect light from the sky through it, and the camera placed and the photograph taken in the ordinary way; or provided one's dark-room is absolutely dark and *one's enlarger emits no stray white light*, the transparency may be placed in it, the filters on the lens of the enlarger, and the negative plate where, ordinarily, the bromide paper is placed. But it is essential that the above conditions prevail, or the plates will be quickly fogged and spoiled.

Perhaps the most convenient method is to construct a long box, placing the camera, ready for photographing, at one end, and the transparency, upright, in an opening a short distance from the other end. On the farther side of the transparency, a pearl or white-matted electric lamp should be suspended, and beyond that, at an angle of 45°, a large white card (12 × 10 in. to illuminate a ¼-plate). It is essential that the card be illuminated evenly. The interior of the box should be painted dead black, and the top edge should project some 2 in. to prevent direct rays of light from the lamp striking the transparencies obliquely. It is important that the rays of light should pass through the transparency at right angles to the surface and not obliquely or loss of colour will result; for the same reason the negative in the camera must be parallel to the transparency.

If a large transparency is to be photographed, it will probably be necessary to use two lamps above in order to get even illumination of the card and their height must be adjusted until the illumination is as even as possible. The elliptical reflectors which were at one time manufactured by Lan-

casters, of Birmingham (and which are probably still to be procured) to fit on to the back of one's own camera to convert it to an enlarger, would probably serve admirably to illuminate transparencies, and would provide a self-contained unit with a known degree of illumination for the purpose.

As with other subjects, it is desirable to use a " step wedge " so that the bromides may be balanced correctly, but here, of course, the wedge must be made on a transparency or lantern plate, as it must be translucent. The wedge can be quite small, a strip $\frac{3}{8}$ of an inch wide cut from a lantern plate will answer for any size of transparency; it should be made by making step exposures (as described on p. 41) on a black-toned lantern plate, the depth approximating to the range of tones of the average transparency. This wedge should be fitted to one side of the aperture in which the transparency will go, so that it is always in position close to the edge of the latter, and preferably should be backed up with a strip of the colour mosaic of the same kind as the transparency to be copied, i.e. if a Finlay then a piece of a Finlay viewing screen should be put behind it, if Dufaycolor, Agfacolor or other kind, then the emulsion of a spoiled result should be washed off in warm water and the mosaic placed behind the wedge. This will ensure the wedge being illuminated by light of approximately the same colour and quality as the image of the transparency itself.

The correct exposure can only be determined by experiment. It is not necessary to stop down the lens very much, though as the red filter exposure is sometimes very short, it is convenient to stop down considerably for this one in order to give an exposure of measurable length, and to open up to a larger aperture for the blue and green filters.

Development is carried out in the usual manner, except that as there is a tendency when copying transparencies for the contrast to be increased, the time of development should be decreased by about one-third, so as to obtain the soft

type of negative required for Trichrome Carbro and the other processes described.

The procedure for making prints from these negatives is, of course, the same as for ordinary colour separation negatives.

CHAPTER V

The Mosaic Screen Processes

The mosaic screen processes, both in glass plate and film form, belong to the " Additive " method of colour photography (pp. 15, 16). There are now a considerable number of these, though only two at the moment of writing are in glass plate form, the Finlay colour and the Agfacolor *plate* processes, the others being on a film base, in roll, film pack and flat cut film.

There are two distinct types of mosaic or reseau employed, regular and irregular. The latter, in the form of dyed starch grains from the potato, are used in the Lumière " Filmcolor " and Lumicolor processes, while the Agfacolor process employs irregular dots of gum or resin for the same purpose.

These dots of colour are exceedingly small, some three million to the square inch, and they are coated upon the glass or film base, covered with an impervious varnish, and on this the panchromatic emulsion is coated.

As the formation of colour in the photograph is due to the part played by these colour dots in both analysing and reforming the colours of the object photographed, it is imperative that the light passing through the lens of the camera should also pass *through* these colour dots *before* it reaches the photographic emulsion. It is therefore essential in all forms of the mosaic screen processes that the base of the plate or film (or in the case of the Finlay colour process the

glass " taking screen " on which the colour dots are printed) should face the lens of the camera, and *not* the emulsion, as in ordinary photography.

The other form of mosaic, or reseau, is regular in pattern. In the case of the Finlay process it is printed in a pattern of tiny squares of red, blue and green (some 90,000 to the square inch) on separate glass plates (i.e. without a photographic emulsion) called " taking " and " viewing " screens respectively, these names indicating their purpose.

In the Dufaycolor process, the regular mosaic is in the form of lines, the blue and green running parallel to one another, and crossed diagonally by parallel red lines, forming a pattern of squares and lines. These are extremely fine and, the lines being 500 to the inch (20 to the millimetre), result in a pattern of colour particles numbering approximately one million to the square inch.

With the introduction of so many processes it becomes difficult to deal adequately with each in a short work of this nature, and the makers issue booklets for their use so admirably full and explicit that it is impossible to improve upon the instructions given therein. The details given here are of a general character, based upon the author's own experience, and meant to be supplemental to the official instructions, and to deal rather with adaptations of one's own apparatus, the lay-out of the dark-room bench, and other seemingly unimportant things which often prove stumbling blocks to the beginner. Otherwise a tendency to length and redundancy is unavoidable.

With the colour material in roll and film pack form needing no compensating filter for daylight exposures, little need be said; the camera as used for monochrome photography fulfils all requirements when the light permits instantaneous exposures. Perhaps the desirability of using some form of lens hood should be stressed, as it becomes of even greater importance in colour work, particularly where strong colour reflections abound. Instructions for making a simple form

of lens hood are given later, and although its use with a compensating filter is indicated, it can obviously be used on the type of filter holder mentioned sans filter.

In the use of plate cameras and dark slides, mention is made in the sections dealing with the Finlay Colour and Dufaycolor processes of the best type to use and how adaptations may be made to suit the peculiarities of each.

With the Agfacolor plate, however, conditions differ. In this process, the emulsion is very thin and easily damaged, and for this reason the use of strong springs on the dark slides must be avoided. If they are strong they should be flattened out so that they press as lightly as possible on the plate, for despite the presence of the protective card the emulsion is so delicate that it is very easily damaged. If the springs cannot be softened (this applies more particularly to single metal plate holders), they should be removed, and a piece of black velvet, cut to fit behind the plate the full size of the opening, should be glued in their place. If velvet is used in this manner one can dispense with the protective card, though the author prefers to use this also as chemical dust may settle upon the velvet, with disastrous results. In loading slides with the Agfacolor plate, it *must* go into the slide so that the glass side will face the lens when in the camera.

Double book-form dark slides are to be preferred, though the writer has used single metal slides for many years with success, but extra care should be taken when inserting the plates to avoid any pressure which will abrade the emulsion. Before the plates are inserted, the dark slides should be dusted out with a soft brush, and then laid on the bench in a convenient position ready for filling before the light is turned out.

If Filmcolor (stiff cut film) or Dufaycolor or Agfacolor ultra cut films are used in double dark (book-form) slides, they may be kept flatly in position against the rebate of the slide by placing an old glass negative behind them. This also prevents damage to the emulsion by the springs of the

dark slide. These films, it must be remembered, differ from the Agfacolor *plate*, in that their emulsions are practically in the normal focal plane, and no allowance need be made for displacement of the emulsion. In the case of the Agfacolor plate (and, too, the Finlay plate) the lens must be racked back, or the glass filter put *behind* the lens *after* focussing, or alternatively the focussing screen itself may be reversed in order to make the necessary allowance for the altered position of the emulsion.

For single metal plate-holders, aluminium sheaths may be obtained from Thos. K. Grant, Polebrooke House, Golden Square, London, which serve admirably for all the cut flat films, and are preferred by the author to any other way of using these films. With these, of course, no alteration in focussing is necessary.

The Compensating Filter

In the mosaic screen processes it is sometimes necessary to use what is known as a " compensating filter " on the lens when making an exposure, the purpose of this being to " even up " the exposure the emulsion receives through the colour dots of the mosaic or reseau.

Although to-day there are processes in which, owing to the modifications made in colour sensitizing by the makers, such a filter is *not* required for certain types of lighting (for example, the Agfacolor Ultra film and the Dufaycolor roll and film packs do *not* require one for ordinary daylight exposures, nor does the Agfacolor *plate* require one for Nitraphot or ½ watt lighting), yet for lights other than these (and in the other processes for *all* kinds of lighting) it is essential that the appropriate compensating filter be employed or a falsification of colour in the result will ensue. The reason for this lies partly in the fact that the panchromatic emulsion, although sensitive to *all* colours, is not equally so, and partly in this, that even if it be possible to so adjust the sensitivity to one particular form of lighting, it still cannot be suited to others, where

the composition of the light differs widely from that it is designed to suit. For example, as mentioned in an earlier chapter, ½ watt lighting contains a much larger proportion of red rays than arc or daylight, and if a film adjusted to suit the latter is used with half-watt *without* its appropriate filter, then the emulsion behind the red dots of the mosaic will receive more exposure than it should do, and the finished result will show a tinge of red over the whole film.

The compensating filter, however, absorbs this excess of red, so that a properly balanced (or compensated) exposure is received over the whole film, and a correct reproduction of the colours of the subject is secured.

Now that there are so many processes available to the worker, with the manufacturer of each supplying a variety of filters suitable for the different kinds of light likely to be used for photography, and for varying conditions of daylight, it is of great importance to be careful to use the proper filter. Conversely, where *no* filter *is* required—that is to say, under the appropriate conditions—no filter must be employed, or an over-corrected result will be obtained.

Compensating filters are obtainable in two forms, as pieces of thin gelatin film, and cemented between glass.

For experimental work, or if one camera is to be devoted entirely to one particular form of colour screen work, the gelatin film answers admirably. It may be cut to fit in between the components of the lens, or for experimental purposes fitted into single cardboard holders similar to those mentioned for the tri-colour filters in Chapter III. When cutting these filters great care must be taken to avoid touching them with the fingers or greasy marks will result.

A piece of paper should be folded which is rather larger than the lens mount; this should be pressed upon the paper and firmly rotated so as to leave a mark corresponding with its circumference. The gelatin filter is placed in between the paper, and holding the latter, cut round inside the mark with a pair of sharp scissors, so that after cutting, the filter can

be dropped into the lens cell. A pair of small tweezers or the point of the scissors should be used to pick up the filter. If used in glass form, the better quality of optical glass should be chosen or distortion may result if the cheapest form is used. It is inadvisable to attempt the binding and cementing of such filters oneself. They are to be bought quite cheaply from the makers of the film or plate in use.

Effect of filter on focussing.—The gelatin filter has no appreciable effect upon the focus of the camera, nor has the glass filter if used *in front* of the lens. Should the latter, however, be used behind the lens (i.e. inside the camera) then an alteration in the point of focus does take place and must be taken into account. The bending of the rays of light as they pass through the glass of the filter throws back the focal point by approximately the thickness of the glass.

This fact can be made use of where colour *plates* are used, but to cover all conditions—film and glass plate, or whether one wants to make use of this peculiarity or to use means to overcome it—necessitates such a lengthy and involved explanation and quotation of so many examples in order to avoid confusion, that the better plan is to consult the booklet of instructions of the particular variety of material employed. Probably from the remarks made elsewhere on this matter, it will be clear to the worker what has to be done in most instances. It is important, however, that focussing should be done accurately, as the softness of definition often so pleasing in monochrome is distinctly less so in colour. The reason for this is obscure, but certainly lack of crisp definition in colour work can be very unpleasant.

In all photography it is desirable that the front surface of the lens should be protected in some way from strong side-light falling upon it. More especially does this apply to the modern large aperture anastigmats, which seldom have the deep projecting flange possessed by the older lenses. It applies with even greater strength to colour photography, especially when the filter is employed on the front of the lens.

It is very advisable to use some form of lens hood, for without it in strong side-light one sometimes obtains a peculiar false coloration of the transparency; moreover, the results lack the brilliance that a good lens hood imparts.

A lens hood can be purchased quite cheaply, but if one is using the filter in a square holder it is very easily made by the photographer.

Making a Lens Hood

To make a lens hood a piece of black velvet ribbon about 1½ in. wide and a little longer than the four sides of the filter holder combined should be laid with the pile downwards. Four pieces of black card (the cards packed with the colour plates answer well) should be cut the same width as the velvet and the same length as one side of the filter holder. One side of each of these is spread thinly with seccotine and they are then laid in a line, sticky side down, upon the velvet, leaving a gap of about 1/10 of an inch between each pair. They should be pressed well down on to the ribbon and covered with a card with a weight on it to dry. When dry, or nearly so, a piece of black ribbon, not necessarily velvet, of the same width and length as the first, should be stuck upon the cards. The whole should then be folded so as to form a square, placed round the filter holder to see that it fits snugly upon it, and the overlapping ends of each piece of ribbon stuck down. The hood can now be folded flat between two pieces of card, taking care that the stuck-down ends of the ribbon are under pressure, and a weight put on top and the whole left to get thoroughly dry.

When quite dry it will probably be found necessary to cut an opening or a gap in one or other of the sides so that it will fit over the projecting clip of the filter holder. Obviously the latter differ in design, but a little ingenuity and a sharp-pointed penknife will produce a very efficient lens hood, which when not in use can be folded flat, taking up very little room in pocket or camera case.

Strongly Coloured Surroundings

When the subject to be photographed is being chosen, care should be taken to avoid trouble from strongly coloured surfaces. If, for instance, a portrait of a lady in a light-coloured dress is to be taken, the sitter should not be placed near a brightly coloured door, nor close to a creeper-covered wall, for the reflection of colour from these becomes exaggerated in the colour transparency, and the side of the face and dress near to it will appear tinged with colour. Another snag to be avoided is the taking of portraits out of doors under a blue sky, for should the sitter have glossy black hair it will appear blue on top. Similarly, water will sometimes take on a stronger tinge of blue than is natural, though this may sometimes be corrected by a slight alteration in the position of the camera.

With the Agfa plate, in such circumstances, e.g. in presence of a deep-blue sky reflected by large areas of water, it is advisable to use the "Deep" instead of the "Normal" compensating filter. The Agfa booklet gives full instructions as to the choice of the suitable filter. It should be pointed out, however, that in the case mentioned, water very often does and should appear blue, whatever the non-colour photographer, who was not present at the time, may say. The writer well remembers the intense blue of the water of Loch Coruisk in the Island of Skye one August day in 1913, and the deep and pure blue of the water in Lulworth Cove in Dorset on one occasion a few years ago, and it must be confessed that the sceptics make him a little impatient at times. To refuse to see beauty in the brilliant and lovely colours of nature is as reprehensible as to be unable to detect it in the lovely nuances of tint and tone, in the pearly mists of autumn or November.

Incidentally it has been the author's experience that this range of filters may be used in another way. Occasionally there seems to be a variation in the colour sensitivity of these plates, as with other forms of photographic material, and, for example, the "Normal" filter used under normal con-

ditions may give an overcorrected result, in which the sky or sea will appear greenish-grey in tone. The use of the " Light " filter instead will often correct this; conversely, if the normal filter gives too cold a result, the " Deep " filter may be used with advantage.

When going on a holiday where a large number of plates may be exposed, it is wise to order them to be all of one batch number and make a test exposure before leaving home. Much disappointment may be avoided if this is done, as the author has proved on more than one occasion.

Composition

The colour worker must be on his guard to avoid being carried away by his ability to reproduce colour, and must refuse to allow himself to photograph it unless it falls harmoniously into his picture. He must look out for the subtle beauties to be found in the more delicate colours, which nature spreads before him as well as the more strident colours in her palette. Those who are able should take advantage of the opportunities offered by art classes, in order to learn how to make the best use of the power that the colour plate puts into their hands.

The time is past when any colour should be photographed, just because it is possible to do so, and workers, for their own benefit as well as for the credit of colour photography itself, should endeavour to raise the artistic standard of their work by studying composition in colour and form as exemplified in the works of art exhibited in our art galleries.

Exposure

With regard to exposure, the reader should study the chapter on the subject, bearing in mind that, with the screen plate of this type, over-exposure is as fatal to success as under-exposure. If exposure is excessive the image will entirely disappear, since, contrary to usual practice, under-exposure produces dense positives, and over-exposure, thin ones.

Development: Temperature

The plates should be developed without undue delay. This does not mean that it is impossible to defer development, but it is better not to do so. Should delay be necessary, as for instance when making the exposures on holiday, care must be taken when repacking the plates to keep the protective card in contact with the emulsion, and to pack them so that as little movement as possible can occur.

As regards the development of these plates, temperature is an important factor, and every endeavour should be made to keep the various baths as near to 65° as possible. The makers have experimented with all types of developers and the formula adopted contains hydroquinone and ammonia, and, as is well known, such a developer has a limited range of activity as far as temperature is concerned, especially with plates of this nature. In hot weather, ice should be used to get the temperature down to the desired level, or failing this, operations should be held over until the weather cools. In very cold weather, if it is impossible to warm the dark-room, one or two bricks *warmed*, not made too hot, in the oven, will retain their temperature for a considerable time. If the dishes are kept on these, the solution may be maintained at the desired temperature.

The Dark-room: Desensitizers

To return now to the dark-room, the worker is advised to adopt the use of a desensitizer as described in the earlier chapters of the book, at any rate at the commencement. As to the continuation of its use, much depends on the purpose in view. If what is aimed at is the production of the finest technical result possible, it is perhaps better not to desensitize. Even when no discoloration is apparent, the use of a desensitizer appears to " clog-up " as it were, the subtle differences of gradation, and affects the brilliance of the result. That this degradation is almost imperceptible is proved by

the fact, that if one mixes transparencies of the same subject, one of which has been desensitized and the other not, it is extremely difficult to tell which is which unless they have been marked in some way. Nevertheless it *is* detectable when one has become accustomed to seeing very fine technical work, and for that reason it cannot be recommended if the finest possible result is required.

On the other hand, if one wants to get the highest average of results from one's exposures, as might well happen where the plate is being employed to make photographs for some special purpose, say for illustrating a lecture on a holiday tour, then undoubtedly it is safer to use the desensitizing bath. To do so will save many an exposure which otherwise would find its way into the dustbin. By its use one can adjust the time of development more easily, and produce the best result the exposure given will yield, which will be better than one can hope to do when working by the time and temperature method in total darkness—or even by the dim light of the special safe-lights employed. With this latter method, after one has accustomed one's eyes to the light, little difficulty will be experienced, but as an aid to the attainment of a sense of confidence and ease in working, there is no doubt that the desensitizer stands one in very good stead.

Of the desensitizers suitable for the purpose, either the Lumière Aurentia, or the Pinacryptol Yellow desensitizer may be used. Some care is needed in the use of the former, because some persons are susceptible to the dye (Aurentia), and in those it may produce a very unpleasant and painful form of eczema. Anyone susceptible in this way should avoid its use. The author, personally, is not sensitive and prefers it to any other desensitizer.

Laying out the Working Bench

If a desensitizer is to be used, then two extra dishes will be required on the dark-room table, one for the desensitizer

itself, and one, a fairly large one for choice, to hold cold water in which to rinse the plate briefly before putting it into the developer. This operation is essential, since if the desensitizer is carried into the developer, although it will not interfere with the first development, it will tend to prevent the blackening of the image in the second development, i.e. after reversal, if the same bath is used.

The bench should be laid out as follows: on the left, the dish with a fairly liberal supply of the desensitizing solution; near by, an opaque card for covering the dish; next, the dish containing the cold water for rinsing purposes; then, the dish for the developer; and, finally, the dish containing the reversing bath.

It is very desirable to have running water available for washing the plate after developing and reversing, though should it be impossible to provide this a large bucket of water beneath the table will serve to give a vigorous swirling motion to the plate for one minute between the baths. Where running water can be used, the tap should have one of the " anti-splash " devices fitted to it so that the water runs in a smooth stream. The tap should only be turned on partially, while the plate itself should be held at an oblique angle to the stream of water, otherwise if the force is too great it may damage the emulsion.

A dark-room clock, or a watch with a fairly large plain seconds hand should be placed where it can be easily seen. If no desensitizer is being used, and a transparent green safe-light is employed, the watch can be put inside the lamp (provided an electric one is employed), and the hands can then be easily seen. An alternative method is to use one of the cheap electric torches, taking off the glass lens cap and inserting between it and the lamp-bulb two pieces of the green and one of the yellow Virida safe-light papers, which can be obtained from Messrs. Lumière, the manufacturers of the Autochrome plate. This forms a very handy method of noting the time and inspecting the plate when desired.

Development

We shall assume that the desensitizing bath is being used. In total darkness, the plate is taken from the dark slide, the black card is removed, and with a wide, soft camel-hair brush, or a piece of folded velvet, the width of the plate, the emulsion is gently wiped across. This is done to remove any dust or particles of the emulsion which the cutting of the plate may have broken off, and which often adhere to the surface. If these are not removed before the plate is wetted it will be found impossible to do so afterwards, and black spots and marks corresponding to them will irrevocably mark the plate.

The plate should then be slid, emulsion side uppermost, beneath the desensitizer. The dish should be covered with the card, the orange or red light turned on, and the time immediately noted.

At the end of 30 seconds the plate should be lifted out and rinsed quickly and thoroughly in the dish of cold water; if close to the light the plate should be shielded from direct rays with the card from the dish, and then put into the second dish.

The dilute portion of the developer, of the strength given in the official instructions, should then be poured on, and the time again noted by the seconds hand of the watch. The plate should then be watched carefully for the first appearance of the image. The general outline of the picture is to be looked for and not such parts as, for instance, the sky in a landscape, or a window in an interior, or the highest lights in a portrait. The time taken for the image to appear having been noted, the dilute developer in the dish should be poured into the measure having the concentrated developer in it, taking care the plate does not fall forward; then the strengthened developer is poured back upon the plate. This method is preferable to taking the plate from the dish, as the less the plate is handled the better. It is obviously important *not* to pour the concentrated developer straight into the dish, as it is impossible to avoid badly marking the plate should this be done.

The makers issue a table for the methodical development of their own particular formulæ, and it is a good plan to copy out the one applicable to the plate in use, on a grease-proof (or other translucent) paper and paste it on to the glass of the dark-room lamp. It can not only be easily seen there, but it will always be there when wanted, a state of affairs which does not always exist in the photographer's dark-room. This table is extremely useful, for not only does it indicate the correct time to develop the plate, but it also shows what correction is necessary in future exposures to avoid the mistake which must have been made in the present case, should the image not appear at the proper time.

When the proper time has elapsed, the plate is taken from the dish and washed for one minute in running water. If it is held under the tap, observe the precautions mentioned earlier to avoid damaging the film.

Reversing Bath

The plate is then put into the reversing bath for at least one minute before turning on the light. As in all similar cases, while the plate remains in the solution, the dish must be rocked to and fro in both directions more or less continuously, if markings are to be avoided.

When a number of plates have to be developed, it is as well to use two dishes of the reversing solution, and at the expiration of the first minute to slip the plate into the second dish. This ensures the complete "eating away" of black silver image in the minimum of time. This should take place in about two minutes, when the plate viewed by transmitted light will appear clearly in the proper colours. The first bath of reverser should be thrown away as soon as it becomes muddy or greenish looking, the second dish being then used as No. 1, a fresh lot of reversing solution being prepared for the final immersion. The plate should not be left in the reversing bath any longer than is necessary to dissolve the black image, nor should it be handled and

looked at unnecessarily. After reversal it is washed again in running water for one minute.

Second Development

The second development then takes place, when the developer used for the first development may be used. Occasionally the plate will be found to have semi-iridescent marks on the surface of the emulsion. These sometimes look very like finger-marks, but the worker is not the cause of them, and the reason for their intermittent appearance is somewhat obscure. When the transparency is viewed by transmitted light they become apparent in the high-lights as light-brown stains and are apt to spoil a delicate slide. It is possible to remove them after the plate has been dried by moistening a small tuft of cotton wool with methylated spirit, squeezing it nearly dry (to avoid any spirit getting beneath the protective varnish and dissolving the colours of the mosaic, these being spirit soluble), and then rubbing *very gently* with a circular motion until the marks disappear. This method needs the exercise of great care to avoid abrading the delicate surface of the emulsion.

A more satisfactory plan is to use the potassium permanganate-sulphuric acid reversing bath instead of the bichromate bath.

The following formula is suitable and is not only effective in preventing this trouble, but gives rather more brilliance to the result.

Reversing Bath

Potassium permanganate	20 grains	2 grammes
Sulphuric acid (conc.)	100 minims	10 c.c.
Water (preferably distilled) to ..	20 oz.	1000 c.c.

If preferred this may be compounded as two solutions, i.e. halving the quantity of water for each solution, and then using equal quantities of each for the working bath. The solutions keep indefinitely in this way.

The bath is used once only, it is useless if turbid.

After reversal, the plate or film is rinsed in cold water and then placed in a clearing bath to remove the brown stain and washed for 2 minutes before redevelopment.

Clearing Bath

Potassium metabisulphite ..	½ oz.	25 grammes
Water to	20 ,,	1000 c.c.

The foregoing instructions apply to cut flat films as well as plates, but rather more care must be taken to avoid damaging them, as they are thinner than glass plates, possibly a little more delicate, and somewhat difficult to pick up from the bottom of the dish.

With Filmcolor and Agfacolor Ultra films it is a good plan to get a strip of thin celluloid, about an inch wide and long enough to go across and down into the dish in use; then, placing it in very hot water to soften it, it should be bent sharply so that it takes the shape of the inside of the dish, the ends projecting either side. If one of these is placed in each dish before the film is immersed, it is an easy matter by lifting one of the projecting ends of the celluloid, to get hold of the colour film without damaging it. Dufaycolor cut film, which at times is prone to curl, is better dealt with as described in the section on this process.

After-treatment

While, as far as possible, after-treatment of the plate is best avoided (for without doubt the technically irreproachable transparency is the result of correct exposure, accurate development and reversal, and speedy drying) yet, as one's work does not invariably result in this most desirable state of affairs it frequently happens that transparencies can be improved by some after-treatment.

Reduction

If, for instance, the plate has been slightly under-exposed and is rather heavy looking and lacking in brilliance, it may

be given a very brief immersion, say 15 or 20 seconds in a weak solution of hypo. The ordinary fixing bath diluted with about three times its own bulk of water will answer. If this does not act sufficiently at the first application, the plate may be put in a second or a third time. The plate must have a full 2 minutes' wash in running water after this treatment before drying.

This method answers well, if the reduction required is slight; if a greater amount is required, a weak bath of Farmer's Reducer should be given. This is prepared by adding a few drops of a 10 per cent solution of potassium ferricyanide to the hypo solution (above) until it is a pale yellow colour. The plate is immersed in this for a few seconds, rinsed under the tap, and *then* examined. It should not be held up with the reducing solution on it, as the action will proceed and may ruin the plate. When sufficiently reduced the plate is washed for 2 minutes as before. The mixed Farmer's Reducer should be used immediately it is mixed, as it does not appear to retain its power of reduction for long, especially after it has once been used.

The author has found this method of reduction preferable to the weak solution of the bichromate reverser which is sometimes advocated, for if this latter is used it is impossible to intensify the slide afterwards, should reduction be carried too far, since the image turns brown upon intensification and the colours are ruined.

Intensification

For intensification the author prefers the "Agfa" Mercurial one-solution intensifier. It is extremely simple to use, the immersion of the plate for a few seconds is all that is required, and as far as permanency is concerned, plates which have been intensified in it some five or six years prior to the time of writing show no signs of fading or change of colour despite their frequent use in the lantern for projection purposes.

Varnishing

It is advisable to varnish the plates before binding them with a cover of glass. Spirit varnishes must *not* be used, as they will dissolve the dyes of the mosaic.

The author prefers the following formula to that recommended by the makers of the Agfa plate, which is rather too thin and is apt to leave streaky markings.

Colour Plate Varnish

Gum damar	10 parts
Crystallizable benzol or carbon tetrachloride ..	100 „

Varnishing appears to be a somewhat tricky problem to many workers, who find it difficult to prevent streaks from showing. The best method of avoiding these is, first to have a fairly large bottle of varnish of a circular shape so that it will stand firmly on the bench. The plate should be balanced emulsion side up on the tips of the fingers of the left hand in a horizontal position. A pool of varnish (a reasonably large amount) should then be poured into the centre of the plate, and the bottle placed in a convenient position on the table. The plate should then be tilted very slightly, first towards one corner and then towards the next, so that the varnish flows evenly over the plate; tilting finally to the corner nearest to the wrist, and then letting the surplus run into the bottle again. Just before it has all run in, the plate should be rocked gently from side to side, while held with the thumb and third finger of the right hand, the movement being lateral and not backwards and forwards, and continued until no more varnish runs from the plate. In this manner streaky markings will be avoided.

It is unnecessary to varnish Dufaycolor films, and for Filmcolor a special varnish prepared by the makers is advisable. The best method to adopt in varnishing these films is to pour the varnish in a perfectly clean porcelain dish and to draw the film through the varnish steadily, clipping it up to dry in a dustless dry place. For the Agfacolor Ultra film

a similar method of varnishing is advised, but the formula given above is suitable for this film.

Binding

The next step is that of binding up with a cover glass. If the transparency is intended to be used in a lantern for projection—the English size for this purpose is $3\frac{1}{4}$ by $3\frac{1}{4}$ in., while the American is $3\frac{1}{4}$ by $4\frac{1}{4}$ in.—the cover glass must be of the same size as the transparency. If the transparency is not intended for lantern projection, but for viewing in the hand, a much better plan is to make the cover glass considerably larger than the transparency itself. This gives little more trouble, and yet shows the picture off to very much better advantage, as an opaque margin of about an inch or so isolates it from the surrounding light.

For the normal method of binding, the special tape for use with the heating iron supplied by the makers of the Autochrome is admirably suited, and preferred by many workers. By its use no moisture gets at the edge of the plate. This is an advantage, for sometimes, if the gummed tape is used and too much moisture is applied to it, there is a tendency for the moisture to attack the colour grains and cause a spreading of colour in towards the centre of the plate, should it be put into the lantern before the binding is thoroughly dry.

In using ordinary gummed tape it will be found convenient either to use the slips ready cut the full length of the four sides, or to cut it that length from the roll, rather than to use the short $3\frac{1}{4}$-in. stripe. The gum should be moistened —the author has not yet come across a more convenient method than the use of the tongue—and the strip laid out on a piece of blotting-paper or a folded newspaper, the gum of course being uppermost. The transparency and cover glass, which should be well polished and thoroughly dry, are now taken and squared off between the fingers, and the lower edge of the two is pressed firmly into the centre of the tape close to its end. The plate is then turned through a right

angle, and the next edge pressed down in its turn. At the same time the finger and thumb are run down the first edge (which will be found to have the tape adhering to it) so as to press the edge of the tape down upon the sides of the glass —not, however, pressing the extreme corners, which should be left projecting.

The plate should be turned over and over until all four edges have had the tape thus applied to them. The projecting corners should then be cut off as close to the plate as possible with a sharp pair of scissors, and the tape rubbed well down with a soft dry cloth.

Care must, of course, be taken during these operations to ensure that the tape is pressed on evenly, with its edges parallel to the sides of the plate, so as to present a perfectly square opening. Nothing looks worse upon the lantern screen than a carelessly bound lantern slide with sides uneven or ragged, and many a slide which otherwise might have received the judges' award at a competition has been thrown out because of its slovenly appearance.

Masking

After binding, the transparency should be carefully inspected to see if the composition can be improved by masking off any part of it. This may very well happen, the reason being that the lens includes more than the eye *looked* at (not saw) when taking the photograph. While it is possible, when binding transparencies made by the combined processes, to put a mask inside, it is by no means an easy matter; for it is not possible to see the picture when it is laid on a sheet of white paper, as can be done with monochrome lantern slides. It is therefore permissible to mask these transparencies on the outside. If the amount of masking is small it can be done with strips of the binding tape, so long as care is taken to see that the top and sides are at right angles to each other, and that the opposite sides of the opening that is left are parallel.

Spotting

Transparencies intended for the lantern should be properly "spotted", i.e. two circular spots of gummed paper (which can be bought ready for use from photographic dealers) should be stuck upon the front top edge of the slide. The spots should be about $\frac{3}{4}$ of an inch from each end, and should not show when the picture is projected upon the screen.

Artificial Light

To colour photography by artificial light the Agfa lends itself particularly well, since with it no special filter is needed for either half-watt or flashlight, if the Agfa flash powder is used. With other lights, as with other processes, the special compensating filter advised by the makers must be used or incorrect colour rendering will result. It is obviously impossible to give any but exceedingly rough estimates of the exposures, as these must necessarily differ according to light, distance of subject, colour of walls, and other data.

An example may be useful as a rough guide, and serve as a starting-point. The writer (using two 100-watt gas-filled lamps, with a white card curved behind them to act as a reflector, and thin nainsook in front to act as a diffusing medium) found that with these lights about 6 ft. from a fruit group on an oaken sideboard, an exposure at F. 11 of 15 minutes gave a fully-exposed plate. A white card was placed on the opposite side to the lamps to act as a reflector on the shadow side. The light was placed at such a height that it fell upon the subject at an angle of about 45°, and slightly on the side of the camera.

A lens hood should always be used, or some efficient means adopted to prevent the light from the lamps shining on the lens.

Many workers are under the impression that only very frontal soft lighting may be used for colour transparency work; this is not the case. Of course the smaller latitude possessed by these plates obviously means that one cannot

deal successfully with as strong a contrast as in monochrome photography, nor indeed is this desirable, but it does not follow that side lighting, producing a reasonable amount of contrast, cannot be attempted. In fact, it is only by such lighting that good modelling can be secured; the really wondefful stereoscopic effect that the colour plate is capable of producing can only be obtained with lighting of this nature.

Flashlight: Kittens and Puppies

Flashlight is another means of producing some "out of the ordinary" photographs in colour, for by flashlight such subjects as kittens and puppies and so on can be secured. Kitten photography can provide exciting sport—certainly so when as many, say, as five are attempted at once.

The plan adopted by the writer is, first of all, to open the windows of the room; this is necessary because, with the comparatively large amount of powder employed, if windows and door are shut the result may be a little alarming —not that there is any danger if only the most elementary common sense is applied to the job in hand.

A small table, just large enough to take the kittens, should be employed, with a suitable background some little distance behind. By a suitable background is meant one contrasting suitably with the subject, but anything violently coloured or obtrusively patterned should be avoided; also, as in other cases when colour photographs are taken, strongly coloured objects near at hand should be removed, or covered over, to avoid colour reflections. The camera should be placed in readiness on the stand, and a piece of newspaper should be placed on the table in the spot it is *hoped* the kittens will occupy, and used for focussing upon. The flash-lamp should now be got ready.

For "still life" subjects, flower studies, &c., if flashlight is employed, a makeshift arrangement of a bent up piece of tin on a pair of steps can be used for the flash-powder, which can be fired with the touch-paper supplied with it;

but for any living subject a proper flash-lamp is essential, and that supplied by the Agfa Company is one of the most satisfactory the author has used. Full directions are supplied with it, and should be carefully studied before use, so that familiarity with the procedure is attained. The powder should then be mixed, care being taken not to do this near a naked light, and the smoker should put his cigarette away while any of the powder is exposed.

If the weather is at all humid the metal tray of the lamp should be warmed as a precaution against possible condensation of moisture on it, which might prevent the powder from igniting.

In measuring out the powder the amount should be put first on a piece of dry smooth paper and then shaken on to the tray; the powder should *never* on any account be poured straight out of the container on to the tray, for should the spring be accidentally released and the powder become ignited, a nasty accident might occur as the whole amount might explode.

The kittens should now be placed on the table, and the shutter of the dark slide removed—then the fun begins. When at last the victims have assumed the desired position and attitudes, the shutter should be opened and the release of the flash-lamp pressed home, when, if your luck has been in, one of the most delightful results of which colour photography is capable will have been secured.

In exposing by flashlight care should be taken to avoid over-exposure through using too much powder; the Agfa booklet gives a table showing the approximate quantities of powder to be used according to the aperture of the lens and the distance of the lamp from the object.

Obviously the new flashlight bulbs, which obviate all trouble from smoke or noise, may be used, with the appropriate filter, though it is true they are somewhat costly, and although, in the instance quoted, the Agfacolor plate was used, any of the processes may be used with equal success.

THE DUFAYCOLOR PROCESS

The Dufaycolor process is a colour film process giving transparencies of great brilliance. By reason of its extraordinary speed, instantaneous exposures can be made with quite inexpensive cameras in reasonably bright daylight. It is available in two forms (1) in roll film and film pack, when no compensating filter for daylight is required—this can be loaded in the camera and exposed in precisely the same manner as ordinary black and white film. It is also to be had (2) as flat cut film suitable for cameras using plate and cut films; in this form a compensating filter for daylight *is* essential.

The speed of the two forms is approximately the same. The necessity for using a filter in the case of the cut film does not mean that it is slower than the other, but rather that it is put forward in this form because the best possible colour correction and highest speed is obtainable in this way. For the professional photographer or anyone who requires the finest possible result, this form is the better, though this is not meant to suggest that the roll and film pack does not produce beautiful results, quite the contrary being the case. So far, however, as any difference exists, the other form has the advantage.

The colour mosaic, or reseau as the manufacturers prefer to call it, is a regular pattern one, and is a triumph of mechanical ingenuity, for it has been found possible to design machinery capable of ruling lines of a fineness of 500 to the inch (20 to the millimetre) on the non-inflammable film base. This degree of fineness, along with the fact that the screen is of regular pattern, thus avoiding the clumping together of particles of one colour, results in a colour mosaic which is quite invisible to the naked eye. Lantern slides made with this process, if *fully exposed* and correctly developed, exhibit a fineness of texture and gradation of tone equalled only by a fine quality monochrome slide. These qualities, added to the excellent colour reproduction, place it in the front rank

of colour mosaic processes. The instruction booklet issued by the manufacturers is well written and extremely complete and needs no amplification here, and it will suffice to briefly epitomise a few personal idiosyncracies.

It may perhaps be pointed out that the film packs and roll films are primarily intended to be processed by the makers, although the amateur can of course do them himself if he wishes, but the roll film at any rate is by no means easy to handle, and the average worker will probably prefer to avail himself of the facilities offered by the official processing station for this type of material, at any rate until he has become proficient in the more easily handled cut film.

The following hints apply more especially to the latter form of material, though they are of course applicable to the other type.

Firstly, with regard to exposure: as in the other mosaic screen processes, so here correctly estimated exposures are by far the most important part of the procedure, although Dufaycolor, with its thickly coated emulsion, has greater latitude in this respect than the more thinly coated processes. Nevertheless, for the finest possible result correct exposure is a *sine qua non.*

The speed of the film is approximately half that of ordinary roll film of the non-colour sensitive kind, e.g. Kodak N.C. roll film or Selo roll film, or about quarter the speed of the orthochromatic variety such as Selochrome, Verichrome, &c. That is to say, the exposures should be about twice that of the former and about four times that of the latter.

If this is done then beautifully translucent films, suitable for lantern projection, will result. Shorter exposures will tend to give somewhat denser results with more intense coloration, more suitable for viewing in the hand than for projection. The makers strongly recommend the use of the photo-electric exposure meters, because these are actuated principally by the light from the brighter parts of the picture, and thus help to avoid excessive over-exposure of these parts, which so often

result in losing all colour in the lightest tones of the picture. Obviously, however, in many subjects, where the range of tones is very great, the exposure given must be a compromise between that suitable for the lightest tones and that needed for the shadows.

The writer prefers to err on the side of over rather than under exposure, as the possibility of improving a thin result by intensification is greater than that of reducing a too dense result.

Incidentally, it is better practice to have a copy made from a too dense result by the makers' own methods—which at present they are not disclosing—rather than risk spoiling a valuable result by reduction. When ordering the copy film, a request must be made that a more transparent result than the original is required.

The usual precautions mentioned on pp. 75 and 76 regarding surroundings and compositions should be borne in mind, and care should be taken that colour is being reproduced which in itself will give modelling and tone differentiation that under similar lighting conditions would be missing from a monochrome result, so that generally speaking flatter lighting may be employed than is generally thought best in black and white work. This is not meant to imply that strong side lighting is to be always avoided; with increased experience much may be done in this direction and with the increased latitude of Dufaycolor, pictures against the light may be attempted successfully if care is taken to avoid any chance of the sunlight striking the lens, and due allowance is made in exposure and development. This last remark means that the exposure should be full enough to permit the shadows to be sufficiently well exposed, so that they are rendered as translucent deep tones and *not* solid black; and that the first development should be shortened to avoid bleaching out the lighter tones of the picture. If this is done, some most beautiful and striking effects may be reproduced.

To come to personal procedure: the writer chiefly uses the

Dufaycolor film in the thicker base, cut film form, in ½-plate and 3¼ in. square (lantern size) sizes.

For the ½-plate size two cameras happen to be available, one with ordinary book-form slides, and here the film is used in between a holder consisting of a sheet of thin flawless glass, which has hinged to it a back of thick celluloid ($\frac{20}{1000}$ in.) with adhesive tape—the Dufaycolor film being put between and loaded into the dark slide, so that when in the camera the glass plate, and the shiny side of the Dufaycolor film, will face towards the lens. If this procedure is adopted the focussing screen of the camera should be reversed, or the other precautions outlined in Chapter IV should be taken to ensure accurate focussing.

The stiff thick base can sometimes be used without the precaution of placing behind glass, provided some means exists to press it firmly against the rebate of the slide, but as there is a slight tendency for it to bulge, if a large aperture lens is likely to be used, it is wise to take this precaution.

The other camera, a ½-plate reflex, has a film magazine carrying thin metal sheaths which the Dufaycolor film goes into without difficulty (shiny side to face towards lens of course), and for the 3¼ in. square camera, the writer has obtained square aluminium film sheaths, which fit into single metal plate-holders and answer admirably for the purpose. For those having a ¼-plate camera similar aluminium sheaths may be obtained.

For the beginner, the use of a desensitizer is strongly recommended, with the adoption of the procedure outlined on pp. 87–90.

In order to avoid any trouble from the curling of the film during processing, the use of Ilford " Film Flat " is to be recommended. This is stiff linen coated on one side with gum, and on the other with a rubber adhesive preparation protected by a cotton covering. For use, the gummed side is well moistened with water and the Film Flat squeegeed down and very firmly rubbed into contact with a piece of glass of

preferably exactly the same size as the Film Flat which, however, should be rather larger than the Dufaycolor film itself. It is then allowed to dry thoroughly before use, some six or seven hours.

To use this for holding the Dufaycolor film, the protective cotton cover is pulled off and the glass is laid on the bench with the adhesive (tacky) side up, and the light turned out. The Dufaycolor film is removed from the dark slide or film sheath and, *without* removing the black paper protecting the emulsion, it is placed (in total darkness or well away from the Ilford " G " safelight) so that with the shiny base *facing towards* the Film Flat, the edge of it can be felt by the finger tips of the left hand to coincide with one edge of the Film Flat covered glass plate. (Note: the glass plate should be at least half an inch longer each way than the Dufaycolor film to be processed.) That edge is then pressed down on to the tacky surface of the Film Flat and the film is lowered down on to the adhesive surface. Then, either with a roller squeegee or with the clean dry thick edge of the palm of the right hand, it is squeegeed or pressed slowly and firmly into contact with the Film Flat; the roller or hand of course being applied to the black protective paper, which can next be pulled at right angles when it will leave the film without pulling this off the Film Flat.

The processing can then be carried out according to the directions—which should be followed carefully—just as if it were a glass plate, and no fear of damage by handling the surface of the film will be incurred.

It may be mentioned in passing that the emulsion is much tougher than is usual with reversible emulsions and has no tendency to frill, so that if this precaution is taken there is no excuse for faults incidental to handling delicate film surfaces; and in handling these the worker accustomed to glass plates will find all the advantages he is accustomed to.

Of the two developers given in the booklet the writer prefers B, the formula given here.

Metol	130 grains	6·5 grammes
Sodium sulphite (anhydrous) ..	2 oz.	50 ,,
Hydroquinone	40 grains	2·0 ,,
Sodium carbonate (crystals) ..	4 oz.	100 ,,
Potassium bromide	50 grains	2·75 ,,
Potassium thiocyanate (sulphocyanide) (pure)	160 ,,	9 ,,
Water up to	40 oz.	1000 c.c.

The chemicals are to be dissolved in the order given, and fresh developer at the above strength used for each film (unless several small films are being processed together on one sheet of Film Flat). Incidentally, after processing and washing, the Dufaycolor film is stripped from the Film Flat, which is rinsed and dried off with a cloth, and when quite dry can be used again and again, as it keeps its tacky qualities for quite a long time if covered with the protective cotton and kept shut up in a box.

The developer given above keeps rather better than the more usual ammonia one, and produces slightly more brilliant transparencies, and for projection especially is to be preferred to the other formula given.

The two alternative methods of development given should be studied and the more suitable chosen; probably the factorial method for the first development is the more generally useful.

The permanganate bleaching bath is, in the author's opinion, definitely better than the bichromate formulæ given, despite the necessity for the clearing bath advocated after, as it gives greater brilliance and, for projection especially, is to be commended. In the case of over-exposure, where a thin result has been obtained, a great improvement is effected by intensification, and the "Agfa" one-solution intensifier mentioned on p. 94 has been found entirely suitable. Where the result is extremely thin, the operation may be repeated several times (after drying between each application) with advantage, and as a safeguard against subsequent loss of the intensification, a final immersion in any clean-working developer, amidol or metol-quinol, may be given.

It should be pointed out that intensification, especially if repeated as above, will not produce a satisfactory result if the original film had its development stopped before a reasonable degree of contrast had been obtained. A thin *flat* film will intensify into a somewhat flat muddy result. For satisfactory results the first development must have been carried on for approximately the normal time required for the type of subject photographed.

When washed, the back of the film should be wiped with soft moist chamois leather, or pad of moist cotton wool, to remove any water drops, or these will leave marks impossible to remove; and the film should be hung in a clip where warm dry air, free from dust, will ensure it drying as rapidly as possible.

There is no need to varnish a Dufaycolor film.

For other treatments and details the worker is referred to the Dufaycolor instruction booklet mentioned earlier.

THE FINLAY PROCESS

Negative Plate and Taking Screen

The Finlay process is a duplicating process. It employs a separate plate with the colour mosaic printed upon it, instead of having emulsion and colour mosaic upon the same plate, as in the combined processes. This separate plate is known as the " taking screen ", and has to be put into the dark slide in front of, and in close contact with, the negative plate.

One of the fundamental necessities for success in the Finlay process is the closest possible contact between the squares of the taking screen and the emulsion of the negative plate. For this reason the dark slides must be fitted with strong springs so that the two plates are pressed tightly together. Furthermore, great care must be taken to prevent any particle of grit, or of glass (which may chip off if the plate and taking screen are forced carelessly into single metal slides) getting between them and so preventing close contact.

As with all panchromatic material it is advisable to work the Finlay negative plate in complete darkness; the plates, taking screens, dark slides, &c., should be placed in a convenient position on the table before the light is turned out.

When the negative plate is taken out of the box, it is placed with the emulsion in contact with the printed side of the taking screen, the tips of the fingers being passed lightly down the edges to see that they are flush and parallel with one another before inserting them into the dark slide. Neglect of this precaution may make it impossible to get the subsequent lantern plate and viewing screen square with one another, and prevent the slide being put into the lantern slide box or carrier. The two are inserted in the dark slide in such a manner that the glass side of the taking screen will face the lens when in the camera.

The negative plates should always be obtained ready " backed "; the slight extra cost is well repaid by the improved quality of the negative; indeed, the author regards the use of such plates as imperative if fine results are desired.

Exposure and Development

The makers' instructions with regard to exposure and development should be carefully studied and followed. The fact that short instantaneous exposures *can* be given with this process should not be taken to imply that short exposures should be the rule, for a well-exposed plate, developed to yield a soft negative full of delicate gradations, should be aimed at; and it may be pointed out that over-exposure, provided it is not excessive, is not so disastrous with this process as with the combined ones.

Printing

After the negative has been developed, fixed, and dried, and before printing is proceeded with, the extreme edges of the emulsion should be felt with the finger-tips. If the slightest roughness or wrinkling up of the emulsion can be

detected, a sharp knife should be passed round to remove them. It is essential, in order to get close contact between the negative and positive plate when in the printing frame, that anything likely to prevent this should be removed.

The printing frame should be a well-made one, with a rebate which is perfectly level all round, and with good strong springs to press the plates closely together.

If a portion only of the negative is to be printed, as for instance when a lantern slide is made from a quarter-plate negative, it is advisable to make an opaque mask of card of the same size as the negative, having an opening in it of the size proposed for the print. The mask must *not*, of course, be placed between the negative and positive plate, but beneath the negative. The purpose of this is to prevent light spreading inwards toward the centre of the picture. Although the effect of this may not be noticeable when printing from a moderately dense negative, yet with the more delicate type of negative, such as this process demands, the leakage of light inwards through the glass edges of the lantern plate will often spoil an otherwise excellent slide.

The printing frame when loaded should always be used at a standard distance from the light source, and records should be kept on the envelope in which the negative is stored, or in a separate book, of the exposure which has been found to be correct, together with the temperature of the room and solutions.

Technical Excellence

The Finlay process is capable of producing exquisite results, but only if proper care is taken to produce a really technically perfect transparency. This should be brilliant, but not *hard*; one should try to mentally visualize what is required—a positive composed of tiny squares of black, grey, and clear glass, and an exposure such that these squares are black where they should be black, grey where grey is necessary, and so on; for if one reflects it is easy to perceive how

fine quality will be spoiled if this gradation is not present. If, through over-exposure, squares which should be clear glass are veiled; or if those which, to prevent unwanted colour passing, should be solid black are grey and translucent, through stopping development too soon in a vain endeavour to save the plate; the result will be a flat and uninteresting colour slide. The colours will be degraded and the slide will be neither a credit to the process, nor be capable of giving that intense pleasure to its maker that a technically perfect colour slide will always do; and it is useless to attempt to console oneself with the reflection that perhaps if it leaves something to be desired from the point of view of technique, it looks rather more artistic because of its softness.

Softness, however, does not consist of muddiness, and the softly brilliant slide that is a joy from the artistic side is also a joy from the technical aspect, and is, if anything, rather more difficult to make than its more brilliant brother.

Step Exposures

The making of the transparency is of so much importance that the worker should be content to make haste slowly. Although at first it may seem rather tiresome to make " step " exposures for each slide, yet the slight extra trouble is well repaid, for not only is the quality of the work improved, but although one may be inclined to doubt it, the *cost* of working is reduced. Actually one wastes many more plates in the end if a sort of hit or miss style is cultivated in arriving at the correct exposure. It is very little more trouble to *begin* with a well thought out system, and careful manner of working. A careless and happy-go-lucky method is very easily got into, but very difficult to get out of. The worker will in the end find the pleasure of his work tremendously increased when he is conscious that his success is the result of care and painstaking effort instead of being merely one fortunate result among many failures. In view of the high cost of plates and screens he is apt to get discouraged, and perhaps

may drop the process altogether if through waste his expenditure of material is excessive.

In making the first exposure, the printing frame should be placed at the standard distance from the light source. It will be found very convenient to have the light immediately above the printing frame. If so desired, it may be in a box so that it is screened from the rest of the room and only shines straight down upon the printing frame, which should in this case be placed face upwards. The light is turned on, and say, 5 seconds' exposure given. Obviously this exposure must necessarily depend upon the strength of the light and the distance of the negative from it, as well as on the density of the negative. It is advisable to avoid very short exposures, which are apt to become uncontrollable. Next, a portion of the negative should be covered with an opaque card, and another 5 seconds given, followed by another, and so on, until all the negative has been exposed in strips.

The plate should then be developed according to the instructions issued by the makers. Remember again that it is never wise to expose any photographic material unnecessarily to light, however "safe" it may be presumed to be, and a piece of card should be laid over the dish during development to shield it from the direct light of the lamp.

After development is completed a short rinse in cold water should be given, followed by fixing in an acid-fixing bath. When fixed, the plate should be taken into white light and examined critically, and the strip which seems most correctly exposed noted—and that exposure given to the positive.

In case it may seem somewhat extravagant to use a whole lantern slide to find the exposure, it may be pointed out that photographic plates are easily cut with the wheel glass-cutter which may be purchased for sixpence or so in the cheap stores. The plate should be laid upon a perfectly level support, with the emulsion face down on a piece of clean paper, and a firm stroke taken with the cutter against a rule; the plate

being given a sharp bend backwards and then forwards, a perfectly clean break will be made. If there should be any tendency for the emulsion to peel off, though this is most unlikely to occur, a cut may be made through the emulsion with a sharp knife opposite the cut on the glass. In this way the plate may be cut into three pieces, and this will then be found a much more economical method of procedure than trying to hit the exposure by guess-work.

Positive and Viewing Screen: Registering

Once the positive has been made, it should be dried in a position where it will be free from any chance of dust settling upon it—beneath a projecting shelf or piece of card, with the emulsion outwards, in an airy room, is perhaps the ideal. When dried, the edge should be scraped free of any projections, and then a viewing screen should be placed upon it, care being taken that the scratch to be found on the screen (if a lantern-sized one is used) is placed in the same direction as the long side of the original negative. This is necessary, since it will only register in one direction of the plate. The two plates, with the emulsion of the transparency in contact with the printed side of the viewing screen, should now be taken between the fingers and held towards the light. If this is done in daylight it is best to stand some way away from the window. The plates should now be moved against one another with a slightly circular movement, when a network of colours will appear; these will form into squares which, as the movement continues, will gradually disappear, then the slide will appear in more or less uniform colour, in all probability not in the correct colours. The plates should then be tilted slightly, first in one direction and then in another, care being taken to hold them tightly pinched together all the time; in one of these directions the correct colours will be seen. Then, since one should have the viewing screen towards one, this should be " squeezed " very gently in that direction. The amount of movement required is exceedingly

small, probably about one six-hundredth of an inch, so that one can only describe the necessary movement as a " squeeze ".

Binding

As soon as correct register has been secured, the plates should be held tightly together with one hand, and a strong " Bull-dog " metal paper-clip should be clipped on one edge, and a second one on the opposite edge. Some pieces of lantern slide binding-tape having been cut into $3\frac{1}{4}$-in. lengths, or whatever length the plates used may be, one of them should now be moistened and applied to one of the free edges, and a second strip to the other free edge; and these should be carefully and thoroughly rubbed down with a soft cloth. When they are practically dry, the clips should now be put on these two sides, and the other edges dealt with similarly.

It should be pointed out that some of the lantern slide binding strips are coated with gum, which makes them quite useless for those colour slides, in which the slightest after-movement will throw them out of register and destroy the colours.

The binding strips known as " The Specialist " made by Messrs. Fry, or Dennisons Lantern Slide binding-tape, will be found excellent for the purpose.

Concluding Remarks

In conclusion, it is the earnest hope of the author that the descriptions given of the various methods of working may not tend to produce the impression that the practice of colour photography is a tedious business. If that should be so, then failure indeed is the result of his efforts. It should be constantly remembered that operations which may take but a few seconds to perform may perhaps need a page to describe in a way which will be intelligible to one unacquainted with the procedure.

The author has indulged in this not altogether inexpensive hobby as an amateur for more than fifteen years, and having

finally taken it up professionally he has not, as many of his friends predicted, found his interest in it wane. The work remains as fascinating and full of interest as ever, and that despite the failures which occasionally still contrive to ward off monotony. It may therefore be hoped that this work will induce others to traverse the paths which have brought so much pleasure, as well as some little profit, to the author.

To those who have not joined a photographic society the author would suggest the omission be repaired without delay. He owes much to the help and advice received from members of various societies and more to that given him on the occasion of the presentation of his first award for a colour photograph by the late Dr. George H. Rodman: " Specialize in this, my boy—don't fritter away what time you have for your hobby in first this branch and then another, but if you wish to attain success, specialize."

And this advice the author would pass on to the reader of this little book.

Filters. Ilford, Ltd., Ilford, E.; Kodak, Ltd., Kingsway, London, W.C.2.

Panchromatic Plates and Films. Ilford, Ltd., Ilford, E.; Kodak, Ltd., Kingsway, London, W.C.2.

Carbro Process. The Autotype Co., Ltd., 59 New Oxford Street, London, W.C.1.

Duxochrome Process. Farquhar & Moloney, 6 Denman Street, London, W.1.

Repeating Backs. The Autotype Co., Ltd.; Messrs. Colour Photographs, Ltd., Victoria Road, Willesden, N.W.10.

Bromide paper for Carbro. Autotype Co., Ltd., Kentmere, Ltd., Stavely, Westmorland.

Filmcolor and Lumicolor. Thos. K. Grant, Ltd., Polebrook House, Golden Square, London.

Agfacolor. Agfa, Ltd., 1–4 Lawrence Street, High Street, London, W.C.2.

Dufaycolor. Ilford, Ltd., Ilford, London, E.

Finlay Colour. Finlay Colour, Ltd., 174 Gresham House, Old Broad Street, London, E.C.2.

INDEX

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